David A. Wells

Engd. for the Annual of Scientific Discovery 1867

Gould and Lincoln, Boston

ANNUAL

OF

SCIENTIFIC DISCOVERY:

OR,

YEAR-BOOK OF FACTS IN SCIENCE AND ART

FOR

1866 AND 1867.

EXHIBITING THE

MOST IMPORTANT DISCOVERIES AND IMPROVEMENTS

IN

MECHANICS, USEFUL ARTS, NATURAL PHILOSOPHY, CHEMISTRY,
ASTRONOMY, GEOLOGY, ZOÖLOGY, BOTANY, MINERALOGY,
METEOROLOGY, GEOGRAPHY, ANTIQUITIES, ETC.

TOGETHER WITH

NOTES ON THE PROGRESS OF SCIENCE DURING THE YEARS, 1865 AND 1866;
A LIST OF RECENT SCIENTIFIC PUBLICATIONS; OBITUARIES
OF EMINENT SCIENTIFIC MEN, ETC.

EDITED BY

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BOSTON:
GOULD AND LINCOLN,
59 WASHINGTON STREET.
NEW YORK: SHELDON AND COMPANY.
CINCINNATI: GEORGE S. BLANCHARD & CO.
LONDON: TRUBNER & CO.
1867.

ROCKWELL & ROLLINS,
PRINTERS AND STEREOTYPERS, BOSTON.

PREFATORY NOTE.

WASHINGTON, D. C., February, 1867.

TO THE READERS OF THE "ANNUAL OF SCIENTIFIC DISCOVERY:"

HAVING been called to the supervision of a branch of the public service, the duties of which are too engrossing and responsible to allow of any diversion of attention or employment, the undersigned is compelled to announce his withdrawal (at least for the present) from the editorial charge and management of the "Annual of Scientific Discovery."

He has, however, the satisfaction of knowing that his withdrawal is not to affect the continued publication of the work; and that, under the guidance of the eminent scientific gentleman whose name appears on the title-page of the present volume, the sphere of usefulness of the "Annual of Scientific Discovery" is certain to be not only maintained, but greatly enlarged.

With no little personal regret at being thus compelled to give up a work which for more than fifteen years has been followed as a labor of love,

I am, most respectfully,

DAVID A. WELLS,

U. S. Commissioner of Revenue.

NOTES BY THE EDITOR,

ON THE

PROGRESS OF SCIENCE FOR THE YEARS 1865 AND 1866.

The years 1865 and 1866 have been uncommonly prolific in scientific discovery, in almost every department of knowledge. This has been mainly due to the activity of Associations for promoting the progress of special branches of knowledge, which not only furnish important and varied contributions to science, but constitute impartial tribunals for the determination of the value of individual researches. Among these, the Royal Society and British Association in England, the Academy of Sciences of France, and the American Association (this year successfully revived after an interval of five years) and the National Academy in this country, stand prominent.

Taking the departments of science in the order adopted in this work, the mechanic and useful arts first claim attention. The successful laying of the new Atlantic telegraph cable, and the picking up and utilizing the old cable, are the greatest engineering achievements of the year 1866, and continue to excite the interest of the scientific world. The completion of the Chicago tunnel under Lake Michigan will doubtless inaugurate a new era in subterranean modes of communication; and the success of the third or centre-rail system over Mt. Cenis will probably ere long do away with the tedious and expensive plans of boring through mountain chains both in Europe and this country.

In marine and locomotive engineering the improvements are chiefly in the direction of economy of fuel by modifications of furnaces and flues, and especially by the due supply of air for complete combustion. Surface condensation increases in the estimation of the best engineers, greatly increasing the economy of marine engines. The use of superheated steam is yet in its infancy,

but it is to be hoped that theoretical fears on this subject will soon be dissipated by successful experience. The use of petroleum as a fuel for steam engines seems to be approaching practical application.

The substitution of steel for iron in various parts of locomotives, and for rails, has added greatly to the permanence of the machinery, and diminished the wear and tear in a remarkable degree. The extensive use of steel in ship-building, especially since the Bessemer process has come into vogue, has contributed much to the strength and safety of sea-going vessels, with diminished weight, and seems likely to restrict the composite system of wood and iron construction to those navigating smooth waters.

The battle of the guns *versus* armor-plates is still waged with great vigor, and the victory just now appears to be on the side of the steel projectiles and chilled shot of Maj. Palliser and others; but this will only give rise to improved machinery, a better selection of material, and better processes of manufacture on the part of the armor-plate makers.

The new gunpowder of Capt. Schultze, made from wood, by a process similar to that of making gun-cotton, bids fair to rival the old explosive for certain purposes. Nitroglycerine and gun-paper have also been successfully introduced, the former for blasting, and the latter for small arms.

In respect to light, heat, chemical affinity, electricity, and magnetism, universal attributes of matter in all its forms, it may be considered as proved that all these forces are so invariably connected *inter se* and with motion, as to be regarded as modifications of each other, and as resolving themselves objectively into motion, and subjectively into that something which produces or resists motion, and which we call force.

Recent researches go to show that magnetism is cosmical, and not merely terrestrial. One of the startling suggestions made by Mayer, as a consequence resulting from the dynamical theory of heat, is that, by the loss of the *vis viva* occasioned by friction of the tidal waves, as well as by their forming a drag upon the earth's rotary movement, the velocity of the earth's rotation must be gradually diminishing, and that thus, unless some undiscovered compensatory action exist, this rotation must ultimately cease, and changes hardly calculable take place in the solar system. M. Delaunay and Mr. Airy consider that part of the acceleration of the moon's mean motion, not at present accounted for by planetary

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disturbances, is due to the gradual retardation of the earth's rotation.

According to Mr. Grove, in his Inaugural Address to the British Association for 1866, from which we quote largely, there are some objections, though not insuperable, against the theory of Mayer, that the heat of the sun is caused by friction or percussion of meteorites falling upon it; but these cosmical bodies have not been ascertained to impinge upon the sun in a definite direction from their gradually lessening orbits. And M. Faye, who has recently investigated the proper motions of the sun-spots, has pointed out many objections to this theory, and attributes them to some general action arising from the internal mass of the sun.

Assuming the undulatory theory to be true, and that light must lose something as light, in its progress from distant luminous bodies, it becomes an interesting question what becomes of the enormous force of light lost, and heat radiated into space, which do not apparently return in the same forms. Force cannot be annihilated; its modes of action in this case are only changed. This is one of the most interesting problems of celestial dynamics, which we wait for some Newton to solve.

The doctrine of the correlation of forces is steadily gaining ground. Many points of great practical importance are connected with this subject, as whether we can produce heat by the expenditure of other forces than those locked up in our coal-beds and forests; whether we can absorb and store up for future use, by chemical or mechanical means, the rays of the sun now wasted for human purposes in the desert and the tropics.

The researches of Prof. Tyndall on radiant heat, and the discoveries of Graham on the increased potential energy of atmospheric air when passed through films of caoutchouc, it becoming richer in oxygen by losing half its nitrogen, are interesting as indications of means for storing up force. The magneto-electric machine of Mr. Wilde, and the electrical machine of Mr. Holz, show how mechanical may be advantageously converted into electrical force. The greatest practical conversion of force is exemplified in the fact that the chemical action of a little salt water upon a few pieces of zinc, as shown in the Atlantic cable, has bound the two hemispheres together by electrical action.

The remarkable results of spectrum analysis, from the labors of Kirchhoff, Bunsen, Huggins, and Miller, have thrown a flood of light upon the structure of the heavenly bodies. These conclusions will be found under the head of "Celestial Chemistry."

The old theories of geological convulsions and cataclysms by which the inequalities of the earth's surface and the many breaks in the geological record were explained, are now supplanted by the modern view of Lyell and others, which refers the changes in the past to causes similar to those now in operation. With this, since the researches of Darwin, has become connected the question, whether, in a geological formation unmistakably continuous, the different characters of the fossils represent absolutely permanent varieties, or may be explained by gradual modifying changes. It is quite possible that many modifications of size and form, regarded as permanent, and on which specific differences have been assumed, may be due to changes in the conditions of existence. The opponents of Darwin's theory have a strong point in the fact that, with the present knowledge of fossil forms, the physical breaks in the strata make it impossible to fairly trace the order of succession of organisms; but, notwithstanding the imperfection of the geological record, the belief widely prevails among geologists that the succession of species bears a definite relation to the succession of strata.

Since Sir John Herschel, more than thirty years ago, proposed to explain the climatal perturbations on the earth's surface, with the attendant geological phenomena, by changes in the eccentricity of the earth's orbit, cosmical studies have been more intimately associated with geology. Mr. Croll has recently shown reason to believe that the climate in the frigid and temperate zones of the earth would depend on whether the winter of a given region occurred when the earth at its period of greatest eccentricity was in aphelion or perihelion — if the former, the annual average of temperatare would be lower, — if the latter, it would be higher than when the eccentricity of the earth's orbit was less, or approached more nearly to a circle — he calculates the difference in the amount of heat, in these two positions, as nineteen to twenty-six. He thus explains the glacial, carboniferous or hot, and the normal or temperate periods, which we observe in geological records; he estimates that it is certainly not less, and probably much more, than one hundred thousand years since the last glacial epoch.

The progress of physiology during the last two years has been great, principally owing to microscopical and chemical investigations. The discovery of development by cells, evincing a simple, uniform law, underlying and working out the very different forms

and structures of vegetable and animal life, marked a new era in physiological science. Says Prof. Huxley, "Surely the knowledge that the tough oak plank, the blade of grass, the lion's claw, the contracting muscle, and the thinking brain, all emanate from simple forms which, so far as we can tell, are perfectly alike,— and further, that the entire plant or animal also emanates from a single form or cell which is undistinguishable from the rudiments of its several parts, is as full of interest, and as suggestive of high thought as any one of the fragments of knowledge which man has worked out for himself in the whole range of physical science; and what better exercise can there be than teaching the operation of the great law of uniformity?"

Organic chemistry has accumulated a vast array of facts which its professors are bringing to bear upon some of the most important questions in physiology, and their habits of investigation and knowledge of the nature of the forces acting within the body have made them umpires in many of the sanitary and even medical questions of the day. Such is the rapid advance of the chemical knowledge of common things, that physicians must be chemists to that degree as to be able to answer questions arising regarding the air, water, food, drink, and medicine which, by means of forces that exist in them, act upon the forces within the human body, and give rise to the phenomena of health and disease. From the researches of Traube, Playfair, E. Smith, Fick and Wislicenus, Frankland, and others, we know that the amount of labor which a man has undergone in twenty-four hours may be approximately arrived at by an examination of the chemical changes which have taken place in his body; "changed forms in matter indicating the anterior exercise of dynamical force." All will admit that muscular action is produced at the expense of chemical changes, but until recently it was generally believed that muscular power is derived from the oxidation of albuminous or nitrogenous substances; but more recent researches, detailed in the text, show that the latter is only an accompaniment and not the cause of the former, and that muscular force is supplied by the oxidation of carbon and hydrogen compounds. Messrs. Fick and Wislicenus, from their experiments in ascending the Faulhorn, state that "so far from the oxidation of albuminous substances being the only source of muscular power, the substances by the burning of which force is generated in the muscles are not the albuminous constituents of those tissues, but non-

nitrogenous substances, either fats or hydrates of carbon, and that the burning of albumen is not in any way concerned in the production of muscular power."

The theory of Darwin, that species are not rigidly limited, and have not been created at various times complete and unchangeable, but have been gradually and indefinitely varied, from external circumstances, from natural efforts to accommodate themselves to surrounding changes, and from the necessity of yielding to force in the struggle for existence, has continually gained ground, and now numbers among its advocates many of the first naturalists of Europe and this country. The opponents of this theory have their strong points in accommodating definitions of a species, the phenomena of hybridity, and the non-occurrence of these changes before our eyes. If species were created as we now see them, the more we subdivide them by extended observation the more we increase the number of the supposed creations; and yet we have no well authenticated instance of a new creation, and in no other operations of nature such a want of continuity, such a perpetually recurring creative miracle. The tendency seems to be to the belief that there are no such natural divisions as species, genera, families, etc., but that they are merely convenient terms for subdivisions, having a permanence which may outlive many generations of man, and yet which are not absolutely fixed. Such is the length of geological periods now admitted, that the phenomena of hybridity may be legitimately explained on the theory of the continuity of succession; the infecundity may just as well be due to physical differences arising from long-continued variation, as to an original organic constitution; indeed, the acknowledged degrees of hybridity are best explained on Darwin's theory. Darwin insists upon time for the changes by natural selection; and no one will pretend, at the present day, to date back the earth's history only a few thousand years. Geology teaches that hundreds of thousands of years do not limit the period of the earth's existence as an abode for living organisms. In the early days of geological science, the numerous gaps in the record of fossil forms would have been a strong argument against the theory of Darwin; certain species seemed to become extinct and new ones to appear without connecting links; but, as page after page of this geological record has been discovered, the gaps become less numerous and less abrupt, and the intermediate forms are gradually being added to form the continuous series.

The more the gaps between species are filled up by the discovery of intermediate varieties, the stronger becomes the argument for transmutation, and the weaker that for successive creations; because the former view then becomes more and more consistent with experience, and the latter more and more inconsistent with it. The investigations of Mr. Bates on the butterflies of the Amazon region, of Mr. Wallace on those of the Malay Archipelago, of Mr. B. D. Walsh on the effect of food in insects, — Sir John Lubbock's diving hymenopterous insect; the discovery of Eozoön at a period inconceivably antecedent to the pre-supposed introduction of life upon the globe; the published opinions of De Candolle and Hooker, in botany; the phases of resemblance to inferior orders which the embryo goes through in its development; the metamorphosis of plants, and the occurrence of rudimentary and useless organs, — all supply strong evidence in favor of the derivative hypothesis. The present more quiet and uniform rate of physical changes would involve a greater degree of fixity in living forms than in the earlier periods of rapid transition. It must also be remembered that only a very small portion of the extinct forms have been preserved as fossils; were the series complete, the question would be solved, and, in the opinion of many good judges, most likely in favor of the derivative hypothesis. The opponents of continuity lay all stress upon the lost links of the palæontological chain, and none upon the few existing and altogether exceptional ones; and the worst of it is, that the chance of filling up the missing links, from the operation of destructive causes, is very small.

The controversy of MM. Pasteur and Pouchet on spontaneous generation had ended in the general belief that the latter was in error, but more recent experiments of Mr. Child again opened the question; the weight of opinion, however, continues to be against the theory of spontaneous generation, or, if heterogeny obtains at all, that it is confined to the most simple structures, such as vibrios and bacteria, the more highly-developed and progressive forms being generated by reproduction.

Meteorites are now acknowledged to be cosmical bodies moving in the interplanetary spaces by gravitation around the sun, and some perhaps around the planets, showing that the universe has not the empty spaces formerly attributed to it, but is studded with smaller planets between the larger and more visible masses. Such as have fallen upon the earth give on analysis metals and

oxides similar to those which belong to our own planet. M. Daubrée, before the French Academy, has given the chemical and mineralogical characters of meteorites, and finds that their similarity to terrestrial rocks increases as we penetrate into the crust of the earth, and that some of our deep-seated minerals, as olivine, serpentine, etc., are almost identical with meteoric constituents. When we consider that the exterior of the earth is oxidated to a considerable extent, there is no cause for wonder that its deoxidated interior should possess a higher specific gravity than the crust.

The asteroids and planets now number ninety-two, and probably the next half century will demonstrate that the now seemingly vacant interplanetary spaces are occupied by many others of these bodies.

Our own satellite has been the subject of rigid scrutiny, yet the question whether the moon possesses any atmosphere cannot be regarded as solved; if there be any, it must be exceedingly small in quantity and highly attenuated. It is believed that there is not oxygen enough in the moon to oxidate the metals of which it is composed, and that the surface which we see is metallic, or nearly so. M. Chacornac's recent observations lead him to the belief that many of the lunar craters were the result of a single explosion, which raised the surface as a bubble, and deposited the *débris* around the orifice of eruption. The lunar eruptions evidently did not take place at one period only, as in many parts one crater is seen encroaching on and displacing others.

It is to be hoped that the achromatic telescope will ere long be freed from its old and great defect, "the inaccuracy of definition, arising from what was termed the irrationality of the spectrum, or the incommensurate divisions of the spectra, formed by flint and crown glass."

The improvements of Mr. Alvan Clark, of Cambridge, Mass., in the construction and local correction of lenses for the telescope, for which the Rumford Medal has recently been awarded by the American Academy, mark a new era in astronomical observation.

Recent discoveries in palæontology prove that man existed on this earth at a period far anterior to that commonly assigned to him. The chipped flints of the earliest races show that their condition was not that of civilization; to these rude implements succeeded more carefully shaped and polished stone weapons, then bronze was used, and, the last, before the historic period, iron.

Civilization, even to the extent of that of the Egyptians and the Central Americans, must have been of very slow growth; as invention is said to march with a geometrical progression, the earliest steps must have been exceedingly slow.

Time is the great element, both in the development of vegetable and animal life, and also in the progress of man from barbarism to civilization; and this must be a primary idea in the consideration of the theory of Darwin. In this relation we will conclude by quoting from the Inaugural Address of Mr. Grove, before alluded to. "The prejudices of education, and associations with the past, are against this (Darwin's theory of the origin of species by natural selection, etc.), as against all new views; and while, on the one hand, a theory is not to be accepted because it is new and *primâ facie* plausible, still, to this assembly, I need not say that its running counter to existing opinions is not necessarily a reason for its rejection; the *onus probandi* should rest on those who advance a new view, but the degree of proof must differ with the nature of the subject. The fair question is, Does the newly-proposed view remove more difficulties, require fewer assumptions, and present more consistency with observed facts, than that which it seeks to supersede? If so, the philosopher will adopt it, and the world will follow the philosopher — after many days." He is strongly in favor of the new theory, disbelieving in *per saltum* or sudden creations, and maintains that continuity is a law of nature, the true expression of the action of Almighty Power, and that we should cease to look for special interventions of the creative act — "we should endeavor from the relics to evoke their history, and, when we find a gap, not try to bridge it over by a miracle."

The readers of the "Annual of Scientific Discovery" will be gratified to possess the fine Portrait of HON. DAVID A. WELLS, U. S. Commissioner of Revenue, and late editor of this work, presented in the present volume.

THE

ANNUAL OF SCIENTIFIC DISCOVERY.

MECHANICS AND USEFUL ARTS.

ATLANTIC TELEGRAPH.

THE greatest achievement, in a scientific point of view, which has occurred during the present year, is the successful laying of the Atlantic Telegraph Cable, from Valentia, on the coast of Ireland, 2,000 miles across the bed of the Atlantic Ocean, to Heart's Content, Newfoundland, electrically uniting Europe and America. This is not only a marked epoch in the progress of science, and a triumph over physical obstacles deemed insurmountable, but it is an event of great international interest, and an inestimable commercial boon—reflecting honor alike upon the skill of the mechanic, the science of the physicist, the intelligence of the seaman, and the liberality of the merchant.

Foremost among the names of those who have contributed to this successful result, is our countryman, Cyrus W. Field, who for nearly thirteen years has labored, through good and evil report, with indomitable energy, not resting till his cherished idea had become a reality.

From his remarks on various occasions, and from scientific journals of England and this country, the following account of the Atlantic Telegraph is condensed by the *Editor*.

Mr. Field, at a banquet given in his honor at New York, Nov. 15, 1866, gave a brief history of this great undertaking, reported in the "New York Times" of Nov. 16th, from which the following are extracts. Says Mr. Field:—

"It is nearly thirteen years since half a dozen gentlemen of this city met at my house for four successive evenings, and around a table covered with maps and charts, and plans and estimates, considered a project to extend a line of telegraph from Nova Scotia to St. Johns, in Newfoundland, thence to be carried across

the ocean. It was easy to draw a line from one point to the other — making no account of the forests and mountains and swamps and rivers and gulfs, that lay in our way. Not one of us had ever seen the country, or had any idea of the obstacles to be overcome. We thought we could build the line in a few months. It took two years and a half. The arduous and costly work was accomplished. A road was cut through 400 miles of wilderness, and after two attempts in 1855 and 1856, a cable, procured in England, was laid across the Gulf of St. Lawrence. Yet we never asked for help outside our own little circle. Indeed, I fear we should not have got it if we had — for few had any faith in our scheme. Every dollar came out of our own pockets. Yet I am proud to say no man drew back. No man proved a deserter; those who came first into the work have stood by it to the end. Of those six men, four are here to-night — Mr. Peter Cooper, Moses Taylor, Marshall O. Roberts, and myself. My brother Dudley is in Europe, and Mr. Chandler White died in 1856, and his place was supplied by Mr. Wilson G. Hunt, who is also here. Mr. Robert W. Lowber was our Secretary. To these gentlemen, as my first associates, it is but just that I should pay my first acknowledgments.

"From this statement you perceive that in the beginning this was wholly an American enterprise. It was begun, and for two years and a half was carried on, solely by American capital. Our brethren across the sea did not even know what we were doing away in the forests of Newfoundland. Our little company raised and expended over a million and a quarter of dollars before an Englishman paid a single pound sterling. Our only support outside was in the liberal character and steady friendship of the Government of Newfoundland, for which we were greatly indebted to Mr. E. M. Archibald, then Attorney-General of that colony, and now British Consul in New York. And in preparing for an ocean cable, the first soundings across the Atlantic were made by American officers in American ships. Our scientific men had taken great interest in the subject. The U. S. ship 'Dolphin,' discovered the telegraphic plateau as early as 1853; and the U. S. ship 'Arctic' sounded across from Newfoundland to Ireland in 1856, a year before H. M.'s ship 'Cyclops,' under command of Captain Dayman, went over the same course. This I state, not to take aught from the just praise of England, but simply to vindicate the truth of history.

"It was not till 1856 — ten years ago — that the enterprise had any existence in England. In that summer I went to London, and there, with Mr. John W. Brett, Mr. Charles Bright, and Dr. Whitehouse, organized the Atlantic Telegraph Company. Science had begun to contemplate the necessity of such an enterprise; and the great Faraday cheered us with his lofty enthusiasm. Then for the first time was enlisted the support of English capitalists; and then the British Government began that generous course which it has continued ever since — offering us ships to complete soundings across the Atlantic, and to assist in laying the cable, and an annual subsidy for the transmission of messages.

The expedition of 1857, and the two expeditions of 1858, were joint enterprises, in which the 'Niagara' and 'Susquehanna' took part with the 'Agamemnon,' the 'Leopard,' the 'Gorgon,' and the 'Valorous'; and the officers of both navies worked with generous rivalry for the same great object. The capital of the Atlantic Telegraph Company (£350,000) — except one-quarter, which was taken by myself — was subscribed wholly in Great Britain. The directors were almost all English bankers and merchants, though among them was one gentleman whom we are proud to call an American — Mr. George Peabody — a name honored in two countries, since he has showered his princely benefactions upon both.

"With the history of the expedition of 1857–8 you are familiar. On the third trial we gained a brief success. The cable was laid, and for four weeks it worked, — though never very brilliantly, — never giving forth such rapid and distinct flashes as the cables of to-day.

"It spoke, though only in broken sentences. But while it lasted no less than 400 messages were sent across the Atlantic. You all remember the enthusiasm which it excited. It was a new thing under the sun, and for a few weeks the public went wild over it. Of course, when it stopped, the reaction was very great. People grew dumb and suspicious. Some thought it was all a hoax; and many were quite sure that it never worked at all. That kind of odium we have had to endure for eight years, till now, I trust, we have at last silenced the unbelievers.

"After the failure of 1858 came our darkest days. When a thing is dead, it is hard to galvanize it into life. It is more difficult to revive an old enterprise than to start a new one. The freshness and novelty are gone, and the feeling of disappointment discourages further effort.

"Other causes delayed a new attempt. This country had become involved in a tremendous war; and while the nation was struggling for life, it had no time to spend in foreign enterprises.

"But in England the project was still kept alive. The Atlantic Telegraph Company kept up its organization. It had a noble body of directors, who had faith in the enterprise, and looked beyond its present low estate to ultimate success. I cannot name them all, but I must speak of our Chairman, — the Right Hon. James Stuart Wortley, — a gentleman who did not join us in the hour of victory, but in what seemed the hour of despair, after the failure of 1858, and who has been a steady support through all these years.

"All this time the science of submarine telegraphy was making progress. The British Government appointed a commission to investigate the whole subject. It was composed of eminent scientific men and practical engineers — Galton, Wheatstone, Fairbairn, Bidder, Varley, and Latimer, and Edwin Clark — with the Secretary of the Company, Mr. Saward — names to be held in honor in connection with this enterprise, along with those of other English engineers, such as Stephenson, and Brunel, and Whitworth, and Penn, and Lloyd, and Joshua Field, who gave time and thought and labor freely to this enterprise, refusing all com-

pensation. This commission sat for nearly two years, and spent many thousands of pounds in experiments. The result was a clear conviction in every mind that it was possible to lay a telegraph across the Atlantic. Science was also being all the while applied to practice. Submarine cables were laid in different seas — in the Mediterranean, in the Red Sea, and in the Persian Gulf.

"When the scientific and engineering problems were solved, we took heart again, and began to prepare for a fresh attempt. This was in 1863. In this country — though the war was still raging — I went from city to city, holding meetings and trying to raise capital, but with poor success. Men came and listened, and said 'it was all very fine,' and 'hoped I would succeed,' but did nothing. In one of the cities they gave me a large meeting, and passed some beautiful resolutions, and appointed a committee of 'solid men' to canvass the city, but I did not get a solitary subscriber! In this city I did better, though money came by the hardest. By personal solicitations, encouraged by good friends, I succeeded in raising £70,000. Since not many had faith, I must present one example to the contrary, though it was not till a year later. When almost all deemed it a hopeless scheme, one gentleman came to me and purchased stock of the Atlantic Telegraph Company to the amount of $100,000. That was Mr. Loring Andrews, who is here this evening to see his faith rewarded. But at the time I speak of, it was plain that our main hope must be in England, and I went to London. There, too, it dragged heavily. There was a profound discouragement. Many had lost before, and were not willing to throw more money into the sea. We needed £600,000, and with our utmost efforts we had raised less than half, and there the enterprise stood in a dead lock. It was plain that we must have help from some new quarter. I looked around to find a man who had broad shoulders, and could carry a heavy load, and who would be a giant in the cause. It was at this time I was introduced to a gentleman, whom I would hold up to the American public as a specimen of a great-hearted Englishman, Mr. Thomas Brassey. I went to see him, though with fear and trembling. He received me kindly, but put me through such an examination as I never had before. I thought I was in the witness-box. He asked every possible question, but my answers satisfied him, and he ended by saying it was an enterprise which ought to be carried out, and that he would be one of ten men to furnish the money to do it. This was a pledge of £60,000 sterling! Encouraged by this noble offer, I looked around to find another such man, though it was almost like trying to find two Wellingtons. But he *was* found in Mr. John Pender, of Manchester. I went to his office one day in London, and we walked together to the House of Commons, and before we got there he said he would take an equal share with Mr. Brassey.

"The action of these two gentlemen was a turning-point in the history of our enterprise; for it led shortly after to a union of the well-known firm of Glass, Elliot & Co. with the Gutta Percha Company, making of the two one grand concern known as 'The Telegraph Construction and Maintenance Company,' which in-

cluded not only Mr. Brassey and Mr. Pender, but other men of great wealth, such as Mr. George Elliot, and Mr. Barclay of London, and Mr. Henry Bewley of Dublin, and which, thus reinforced with immense capital, took up the whole enterprise in its strong arms. We needed, I have said, £600,000, and with all our efforts in England and America we raised only £285,000. This new company now came forward, and offered to take the whole remaining £315,000, besides £100,000 of the bonds, and to make its own profits contingent on success. Mr. Richard A. Glass was made Managing Director, and gave energy and vigor to all its departments, being admirably seconded by the Secretary, Mr. Shuter.

"A few days after half a dozen gentlemen joined together and bought the 'Great Eastern,' to lay the cable; and at the head of this company was placed Mr. Daniel Gooch, a member of Parliament, and Chairman of the Great Western Railway, who was with us in both the expeditions which followed.

"The good fortune which favored us in our ship favored us also in our commander. Many of you know Capt. Anderson, who was for years in the Cunard line. How well he did his part in two expeditions the result has proved.

"Thus organized, the work of making a new Atlantic cable was begun. The core was prepared with infinite care, under the able superintendence of Mr. Chatterton and Mr. Willoughby Smith, and the whole was completed in about eight months. As fast as ready, it was taken on board the 'Great Eastern' and coiled in three enormous tanks, and on the 15th of July, 1865, the ship started on her memorable voyage.

"I will not stop to tell the story of that expedition. For a week all went well; we had paid out 1,200 miles of cable, and had only 600 miles further to go, when, hauling in the cable to remedy a fault, it parted and went to the bottom. That day I can never forget—how men paced the deck in despair, looking out on the broad sea that had swallowed up their hopes; and then how the brave Canning for nine days and nights dragged the bottom of the ocean for our lost treasure, and, though he grappled it three times, failed to bring it to the surface. The story of that expedition, as written by Dr. Russell, who was on board the 'Great Eastern,' is one of the most marvellous chapters in the whole history of modern enterprise. We returned to England defeated, yet full of resolution to begin the battle anew. Measures were at once taken to make a second cable, and fit out a new expedition; and with that assurance I came home last autumn.

"In December I went back again, when lo, all our hopes had sunk to nothing. The Attorney-General of England had given his written opinion that we had no legal right, without a special act of Parliament (which could not be obtained under a year), to issue the new 12 per cent. shares, on which we relied to raise our capital. This was a terrible blow. The works were at once stopped, and the money which had been paid in returned to the subscribers. Such was the state of things only ten months ago. I reached London on the 24th of December, and the next day was

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not a 'merry Christmas' to me. But it was an inexpressible comfort to have the counsel of such men as Sir Daniel Gooch and Sir Richard A. Glass; and to hear stouthearted Mr. Brassey tell us to go ahead, and, if need were, he would put down £60,000 more! It was finally concluded that the best course was to organize a new company, which should assume the work, and so originated the Anglo-American Telegraph Company. It was formed by ten gentlemen who met around a table in London, and put down £10,000 apiece. The great Telegraph Construction and Maintenance Company, undaunted by the failure of last year, answered us with a subscription of £100,000. Soon after the books were opened to the public, through the banking-house of J. S. Morgan & Co., and in fourteen days we had raised the whole £600,000. Then the work began again, and went on with speed. Never was greater energy infused into any enterprise. It was only the 1st day of March that the new company was formed, and was registered as a company the next day; and yet such was the vigor and dispatch that in five months from that day the cable had been manufactured, shipped on the 'Great Eastern,' stretched across the Atlantic, and was sending messages, literally swift as lightning, from continent to continent.

"Yet this was not a 'lucky hit'—a fine run across the ocean in calm weather. It was the worst weather I ever knew at that season of the year. We had fogs and storms almost the whole way. Our success was the result of the highest science combined with practical experience. Everything was perfectly organized, to the minutest detail. We had on board an admirable staff of officers; such men as Halpin and Beckwith; and engineers long used to this business, such as Canning, and Clifford, and Temple; and electricians, such as Prof. Thomson, of Glasgow, and Willoughby Smith, and Laws; while Mr. C. F. Varley, our companion of the year before, who stands among the first in knowledge,in practical skill, remained with Sir Richard Glass at Valentia, to keep watch at that end of the line; and Mr. Latimer Clark, who was to test the cable when done. Of these gentlemen, Prof. Thomson, as one of the earliest and most eminent electricians of England, has received the distinction of knighthood. England honors herself when she thus pays honor to science; and it is fit that the government which honored chemistry in Sir Humphry Davy, should honor electrical science in Sir William Thomson.

"But our work was not over. After landing the cable safely at Newfoundland, we had another task—to return to mid-ocean and recover that lost in the expedition of last year. This achievement has perhaps excited more surprise than the other. Many even now 'don't understand it,' and every day I am asked 'how it was done?' Well, it does seem rather difficult to fish for a jewel at the bottom of the ocean, two and a half miles deep. But it is not so very difficult—when you know how. You may be sure we did not go a-fishing at random, nor was our success mere 'luck;' it was the triumph of the highest nautical and engineering skill. We had four ships, and on board of them some of the

best seamen in England, men who knew the ocean as a hunter knows every trail in the forest.

"There was Capt. Moriarty, who was in the 'Agememnon' in 1857–8. He was in the 'Great Eastern' last year, and saw the cable when it broke; and he and Capt. Anderson at once took their observations so exact that they could go right to the spot. After finding it, they marked the line of the cable by a row of buoys; for fogs would come down, and shut out sun and stars, so that no man could take an observation. These buoys were anchored a few miles apart. They were numbered, and each had a flag-staff on it, so that it could be seen by day; and a lantern by night. Thus having taken our bearings, we stood off three or four miles, so as to come broadside on, and then casting over the grapnel, drifted slowly down upon it, dragging the bottom of the ocean as we went. At first it was a little awkward to fish in such deep water, but our men got used to it, and soon could cast a grapnel almost as straight as an old whaler throws a harpoon. Our fishing-line was of formidable size. It was made of rope, twisted with wires of steel, so as to bear a strain of 30 tons. It took about two hours for the grapnel to reach bottom, but we could tell when it struck. I often went to the bow, and sat on the rope, and could feel by the quiver that the grapnel was dragging on the bottom two miles under us. But it was a very slow business. We had storms and calms and fogs and squalls. Still we worked on, day after day. Once, on the 17th of August, we got the cable up, and had it in full sight for five minutes, a long, slimy monster, fresh from the ooze of the ocean's bed, but our men began to cheer so wildly that it seemed to be frightened, and suddenly broke away, and went down into the sea. This accident kept us at work two weeks longer; but, finally, on the last night of August, we caught it. We had cast the grapnel thirty times. It was a little before midnight on Friday night that we hooked the cable, and it was a little after midnight Sunday morning when we got it on board. What was the anxiety of those twenty-six hours! The strain on every man's life was like the strain on the cable itself. When finally it appeared, it was midnight; the lights of the ship, and in the boats around our bows, as they flashed in the faces of the men, showed them eagerly watching for the cable to appear on the water. At length it was brought to the surface. All who were allowed to approach crowded forward to see it. Yet not a word was spoken; only the voices of the officers in command were heard giving orders. All felt as if life and death hung on the issue. It was only when it was brought over the bow and on to the deck that men dared to breathe. Even then they hardly believed their eyes. Some crept toward it to feel of it, to be sure it was there. Then we carried it along to the electricians' room, to see if our long sought for treasure was alive or dead. A few minutes of suspense, and a flash told of the lightning current again set free. Then did the feeling long pent up burst forth. Some turned away their heads and wept. Others broke into cheers, and the cry ran from man to man, and was heard down in the engine-rooms, deck below deck, and from the

boats on the water, and the other ships, while rockets lighted up the darkness of the sea. Then with thankful hearts we turned our faces again to the west. But soon the wind rose, and for thirty-six hours we were exposed to all the dangers of a storm on the Atlantic. Yet, in the very height and fury of the gale, as I sat in the electricians' room, a flash of light came up from the deep, which, having crossed to Ireland, came back to me in mid-ocean, telling that those so dear to me, whom I had left on the banks of the Hudson, were well, and following us with their wishes and their prayers. This was like a whisper of God from the sea, bidding me keep heart and hope. The 'Great Eastern' bore herself proudly through the storm, as if she knew that the vital cord which was to join two hemispheres hung at her stern; and so, on Saturday, the 7th of September, we brought our second cable safely to the shore.

"Having thus accomplished our work of building an ocean telegraph, we desire to make it useful to the public. To this end, it must be kept in perfect order, and all lines connected with it. The very idea of an electric telegraph is, an instrument to send messages instantaneously. When a dispatch is sent from New York to London, there must be no uncertainty about its reaching its destination, and that promptly. This we aim to secure. Our two cables do their part well. There are no way-stations between Ireland and Newfoundland where messages have to be repeated, and the lightning never lingers more than a second in the bottom of the sea. To those who feared that they might be used up or wear out, I would say, for their relief, that the old cable works a little better than the new one, but that is because it has been down longer, as time improves the quality of gutta percha. But the new one is constantly growing better. To show how delicate are these wonderful cords, it is enough to state that they can be worked with the smallest battery power. When the first cable was laid in 1858, electricians thought that to send a current 2,000 miles, it must be almost like a stroke of lightning. But God was not in the earthquake, but in the still, small voice. The other day Mr. Latimer Clark telegraphed from Ireland across the ocean and back again, with a battery formed in a lady's thimble! And now Mr. Collett writes me from Heart's Content: 'I have just sent my compliments to Dr. Gould, of Cambridge, who is at Valentia, with a battery composed of a gun-cap, with a strip of zinc, excited by a drop of water, the simple bulk of a tear!' A telegraph that will do that, we think nearly perfect. It has never failed for an hour or a minute. Yet there have been delays in receiving messages from Europe, but these have all been on the land lines or in the Gulf of St. Lawrence, and not on the sea cables. It was very painful to me, when we landed at Heart's Content, to find any interruption here; that a message which came in a flash across the Atlantic should be delayed twenty-four hours in crossing 80 miles of water. But it was not my fault. My associates in the Newfoundland Company will bear me witness, that I entreated them a year ago to repair the cable in the Gulf of St. Lawrence, and to put our land lines in perfect order.

But they thought it more prudent to await the result of the late expedition before making further large outlay. We have therefore had to work hard to restore our lines. But in two weeks our cable across the Gulf of St. Lawrence was taken up and repaired. It was found to have been broken by an anchor in shallow water, and, when spliced out, proved as perfect as when laid down ten years ago. Since then a new one has been laid, so that we have there two excellent cables.

"On land the task was more slow. You must remember that Newfoundland is a large country; our line across it is 400 miles long, and runs through a wilderness. In Cape Breton we have another of 140 miles. These lines were built twelve years ago, and we waited so long for an ocean telegraph that they have become old and rusty. On such long lines, unless closely watched, there must be sometimes a break. A few weeks ago, a storm swept over the island, the most terrific that had been known for twenty years, which strewed the coast with shipwrecks. This blew down the line in many places, and caused an interruption of several days. But it was quickly repaired, and we are trying to guard against such accidents again. For three months we have had an army of men at work, under our faithful and indefatigable Superintendent, Mr. A. M. Mackay, rebuilding the line, and now they report it nearly complete. On this we must rely for the next few months. But all winter long these men will be making their axes heard in the forests of Newfoundland, cutting thousands of poles, and as soon as the spring opens will build an entirely new line along the same route. With this double line complete, with frequent station-houses, and faithful sentinels to watch it, we feel pretty secure. At Port Hood, in Nova Scotia, we connect with the Western Union Telegraph Company, which has engaged to keep as many lines as may be necessary for European business. This we think will guard against failures hereafter. But to make assurance doubly sure, we shall in the spring build still another line by a separate route, crossing over from Heart's Content to Placentia, which is about 100 miles, along a good road, where it can easily be kept in order. From Placentia a submarine cable will be laid across to the French island of St. Pierre, and thence to Sydney, in Cape Breton, where again we strike a coach-road, and can maintain our lines without difficulty. Thus we shall have three distinct lines, with which it is hardly possible that there can be any delay. A message from London to New York passes over four lines: from London to Valentia; from Valentia to Heart's Content; from there to Port Hood; and from Port Hood to New York. It always takes a little time for an operator to read a message and prepare to send it. For this allow five minutes at each station; that is enough, and I shall not be content till we have messages regularly from London in twenty minutes. One hour is ample (allowing ten minutes each side for a boy to carry a dispatch) for a message to go from Wall Street to the Royal Exchange, and to get an answer back again. This is what we aim to do. If for a few months there should be occasional delays, we ask only a little patience, remembering that our

machinery is new, and it takes time to get it well oiled and running at full speed. But after that, I trust we shall be able to satisfy all the demands of the public.

"A word about the tariff. Complaint has been made that it was so high as to be very oppressive. I beg all to remember, that it is only three months and a half since the cable was laid. It was laid at a great cost and a great risk. Different companies had sunk in their attempts $12,000,000. It was still an experiment, of which the result was doubtful. This, too, might prove a costly failure. Even if successful, we did not know how long it would work. Evil prophets in both countries predicted that it would not last a month. If it did, we were not sure of having more than one cable, nor how much work that one could do. Now these doubts are resolved. We have not only one cable but two, both in working order; and we find, instead of five words a minute, we can send fifteen. Now we are free to reduce the tariff. Accordingly, it has been cut down one-half, and I hope in a few months we can bring it down to one-quarter. I am in favor of reducing it to the lowest point at which we can do the business, keeping the lines working day and night. And then, if the work grows upon us so enormously that we cannot do it, why, we must go to work and lay more cable."

In addition to the preceding remarks of Mr. Field, a few additional details may well be added to complete the history. Four attempts were made to lay a cable across the Atlantic before success was attained. In the first attempt, in 1857, the cable gave way owing to a strain being put on the paying-out machinery, by the sudden dip of the Irish bank, which the apparatus was neither strong enough nor flexible enough to withstand. The second attempt was made in 1858, when the "Agamemnon" and the "Niagara" met in mid-ocean, effected a splice, and steering in opposite directions ultimately laid the cable, which in a few weeks transmitted about 400 messages, and then failed. The attempts of 1865 and 1866 have been sufficiently described by Mr. Field. The great fact that a cable could be laid between Europe and America, and that messages could be sent and received through its length, was practically demonstrated in 1858; the failure of the cable of 1865 was due to mechanical causes, evident enough and easily remedied, as the success of the cable of 1866 fully shows.

The cable of 1858 had for a conductor a copper strand of seven wires, six laid around one; weight, 107 lbs. per nautical mile. The insulator was of gutta percha, laid on in three coverings; weight, 261 lbs. per nautical mile. The outer coat was composed of 18 strands of charcoal iron-wire, each strand made of seven wires, twisted six around one, laid equally around the core, which had previously been padded with a serving of tarred hemp. Breaking strain, three tons five cwt.; capable of bearing its own weight in a trifle less than five miles depth of water. Length of cable, 2,174 nautical miles; diameter, five-eighths of an inch. In the cable of 1865, the conductor was a copper strand of seven wires, six laid around one; weight, 300 lbs. per nautical mile;

embedded in Chatterton's compound. Insulation was effected with gutta percha and Chatterton's compound. Weight, 400 lbs. per nautical mile. The outer coat was 10 wires drawn from Webster and Horsfall's homogeneous iron, each wire surrounded with tarred Manila rope, and the whole laid spirally around the core, which had previously been padded with a serving of tarred jute yarn. Breaking strain, seven tons, 15 cwt.; capable of bearing its own weight in 11 miles depth of water. Length of cable, 2,300 nautical miles; diameter, one inch.

The cable of 1866 has for a conductor a copper strand of seven wires, six laid around one; weight, 300 lbs. per nautical mile; embedded for solidity in Chatterton's compound, The insulator is four layers of gutta percha laid on alternately with thinner layers of Chatterton's compound; weight, 400 lbs. per nautical mile. The outer coat is 10 solid wires drawn from Webster and Horsfall's homogeneous iron and galvanized, each wire surrounded separately with five strands of white Manila yarn, and the whole laid spirally around the core, which had previously been padded with a serving of tarred hemp. The breaking strain is eight tons two cwt., and it is capable of bearing its own weight in 12 miles depth of water. The length of this cable is 2,730 nautical miles, part of which was to be used for completing the cable that parted in 1865. Diameter, one inch.

In laying the Atlantic cables, four main risks had to be encountered, all of which in the present one have been successfully passed through; 1st, the successful and rapid laying of the shore end; 2d, passing down the tremendous submarine incline known as the "Irish bank;" 3d, passing over a short steep valley, where the water sinks to almost as great a depth as in mid-ocean; 4th, and greatest, the laying of the cable for a distance of more than 100 miles through a depth of 2,400 fathoms, or 15,000 feet of water; this passed over, the ocean begins gradually to shallow to 100 fathoms on the Newfoundland coast. The present cable was landed on the American coast in 50 fathoms in Heart's Content Bay, one of the most easterly spurs of rocky headland on the south of Newfoundland; the place chosen for its landing is a deep, rocky inlet, similar to but much larger than Foilhommerum Bay, on the Irish end of the cable; this is more sheltered than Bull's Bay, where the cable of 1858 was successfully landed.

The European shore end of the cable of 1866 was landed at Foilhommerum Bay, on the coast of Ireland, July 7, 1866, at noon; by 3 A. M. of the 8th, the full length of 30 miles was paid out, signalled through, and its insulation and conductivity found perfect. On July 12th, the "Great Eastern" commenced making the splice with buoyed shore end: as soon as that was completed and found perfect, the great work of laying the cable commenced. For the first 250 miles, that is till over the "Irish bank," the cable made in 1865 was used, after that the new cable only; the reason for making this difference was that the new cable is more strongly made than that of 1865, and was therefore reserved for the deepest water. The route taken was 30 to 35 miles south of the broken

cable of last year, so that in grappling for its recovery, there would be no danger of picking up the new one.

One of the the most remarkable circumstances connected with the laying of the cable of 1866 is the directness of the route taken by the Great Eastern, and the small percentage of slack of the cable paid out, compared with the distance run.

The log of the steamer shows:

Saturday, 14*th*. — Distance run, 108 miles; cable paid out, 116 miles.

Sunday, 15*th*. — Distance run, 128 miles; cable paid out, 139 miles.

Monday, 16*th*. — Distance run, 115 miles; cable paid out, 137 miles.

Tuesday, 17*th*. — Distance run, 118 miles; cable paid out, 139 miles.

Wednesday, 18*th*. — Distance run, 105 miles; cable paid out, 125 miles.

Thursday, 19*th*. — Distance run, 122 miles; cable paid out, 129 miles.

Friday, 20*th*. — Distance run, 117 miles; cable paid out, 127 miles.

Saturday 21*st*. — Distance run, 122 miles; cable paid out, 136 miles.

Sunday, 22*d*. — Distance run, 123 miles; cable paid out, 133 miles.

Monday, 23*d*. — Distance run, 121 miles; cable paid out, 138 miles.

Tuesday, 24*th*. — Distance run, 121 miles; cable paid out, 135 miles.

Wednesday, 25*th*. — Distance run, 112 miles; cable paid out, 130 miles.

Thursday, 26*th*. — Distance run, 128 miles; cable paid out, 134 miles.

Friday, 27*th*. — Distance run, 112 miles; cable paid out, 118 miles; which, with shore end off Valentia, distance 27 miles, cable paid out 29 miles, makes distance run 1,669 miles, and paid out, 1,864 miles.

On the 29th of July, the New York papers were supplied with the news from Central Europe only 30 hours old.

One of the most remarkable feats of engineering of any age was the picking up of the cable of 1865, lost at sea, August 2d; at the time of parting, 1,213 miles of cable had been paid out, and all attempts to regain it had been useless on account of the inefficacy of the apparatus used. Having laid the new cable, the "Great Eastern" sailed Aug. 9th, to pick up the old. The dragging for the cable commenced Aug. 12th, resulting in bringing it to the surface on the 17th; it slipped from its fastenings and sunk, four times; but on the fifth trial, after casting the grapnel 30 times, a permanent union was made with the coil on board the "Great Eastern," on September 2d. It was found uninjured and in perfect working order. The grappling ropes were 20 miles long, seven and a half inches in circumference, of the same strands of the

cable; the wire being of steel running through the Manila covering.

The new cable is superior to the old in strength and conductivity, from its enlarged copper wire, and especially by its increased and more carefully guarded insulation. In consideration of these qualities, of the delicate instruments for detecting faults and for working through them when detected, and of the high degree of perfection to which electrical science as applied to telegraphy has now attained, it may be confidently asserted that the new Atlantic cable will be permanently successful.

Says the "New York Independent:" "On Monday, July 30, Mr. Field received a message of congratulation from Mr. Ferdinand de Lesseps, the projector of the Suez Canal. It was dated at Alexandria, in Egypt, the same day, at half-past 1 P. M., and received in Newfoundland at half-past 10 A. M. Let us look at the globe, and see over what a space that message flew. It came from the land of the Pharaohs and the Ptolemies; it passed along the shores of Africa, and under the Mediterranean Ocean more than a thousand miles, to Malta; it then leaped to the continent of Europe, and shot across Italy, over the Alps and through France, under the English Channel to London; it then flashed across England and Ireland, till from the cliffs of Valentia it struck straight into the Atlantic, darting down the submarine mountain which lies off the coast, and over all the hills and valleys which lie beneath the watery plain, resting not till it touched the shore of the 'New World.' In that morning's flight it had passed over *one-fourth* of the earth's surface, and so far outstripped the sun in its course that *it reached its destination three hours before it was sent!* To understand this, it must be remembered that the earth revolves from west to east, and when it is sunrise here it is between 8 and 9 o'clock in Alexandria, in Egypt; and when it is sunset here, it is nearly 9 o'clock in the evening there."

THE NORTH ATLANTIC TELEGRAPH.

The magnitude and serious nature of the transmitting difficulties existing in all long unbroken sea lines, has led to the construction of what is known as the Russian-American line, — a land line of telegraph intended to reach New York from St. Petersburg by wires through Siberia and on to San Francisco, with a short sea section across Behring's Straits, a total distance of about 12,000 miles. This Russian-American line is already far advanced towards completion. But by far the most important line of telegraphic communication between England and America is that to be immediately carried into effect *via* Scotland, the Faroe Islands, Iceland, Greenland, and the coast of Labrador; and known as the North Atlantic Telegraph. A glance at the map in the direction pointed out will at once show that convenient natural landing stations exist, breaking up the cable into four short lengths or sections, instead of the necessitous employment of one continuous length, as between Ireland and Newfoundland. It will also be found that the aggregate lengths of these sections is within a very few miles the same as that of the Anglo-American cable. Not

only will this subdivision of the cable reduce mechanical risks in submerging, but, what is of far more importance, the retardation offered to the passage of the current through the several short sections is almost as nothing when compared with that of the unbroken length of 2,000 miles. Speed of transmission is obtained; and by that means a reduced tariff for public transmissions over the wire. Indeed, such will be the advantages gained in this respect that the present rate by the Anglo-American line of 20s. per word, will be charged on the new route at 2s. 6d., or even a less sum. In examining more closely the nature of this intended northern line, it will be found that the lengths of the several sections of cable between England and America are as follows: Scotland to the Faroe Isles, 250 miles; Faroe to Iceland, 240 miles; Iceland to Greenland, 750 miles; Greenland to Labrador, 540 miles; or, in round numbers about 1,780 miles. The several lengths of cable will be connected together by special land lines through the Faroes (27 miles), and in Iceland (280 miles), and a length of about 600 miles of land wire to be erected in Labrador, will complete the circuit, with the existing American system, on to New York. The average depth of the ocean between Scotland and the Faroe Isles is only 150 fathoms, the greatest depth 683 fathoms. Between the Faroes and Iceland, 250 fathoms, with about the same maximum depth. Between Iceland and Julianshaad, the intended landing-place of the cable in Greenland, the greatest depth is 1,550 fathoms, and between Greenland and Labrador rather over 2,000 fathoms. These lengths of cable and depths of ocean are both not only navigable, but practicable; and no difficulties in the working exist that are not already known by reference to the practical working of existing cables under the conditions of similar lengths and depths. As regards the presence of ice, it must be remembered that it is only at certain seasons of the year that the southwest coast of Greenland is closed by the ice; at other times this ice breaks up, and the coast is accessible to the Danish and other trading vessels frequenting the port and harbor of Julianshaad, the proposed station and landing-place of the cables, and at such times the cables will be laid. Reference to the depth of the soundings up the Julianshaad fjiord will at once indicate the security of the shore ends of the cables from interference from ice when submerged. The landing-places of the cable in Iceland are likewise in no way liable to be disturbed by ice of such a nature as to cause damage to the cable; and on the Labrador coast, the risk of injury to the cable cannot be considered greater than that to which the Anglo-American shore ends are exposed in the vicinity of Newfoundland Bank.—J. HOLMES, *in Reports of British Association for* 1866.

TUNNEL UNDER LAKE MICHIGAN AT CHICAGO, ILL.

The following account of one of the most remarkable and successful feats of American engineering is compiled from various sources, principally the Reports of the Board of Public Works, Chicago, the "Scientific American," and the Boston "Commonwealth." This work is now virtually completed, and for boldness

of conception and engineering skill can compare with the proudest achievements of any age or country. The growth of the city of Chicago has been marvellous, even for America, and its water supply, always insufficient, and of late years unwholesome from the filth poured into the lake near the shore by the sewers, had become a source of great anxiety to its citizens, when it was proposed to take water from the lake two miles from shore, and conduct it to the city through a tunnel under the bed of the lake. Many engineers doubted the practicability of the undertaking, and the estimates of its probable cost varied from $250,000 to $6,000,000. Surveys of the lake bed by means of an auger inclosed in a tube, revealed the favorable circumstance of a continuous underlying stratum of hard blue clay. The contract was awarded to Messrs. Dall and Gowan in October 1863, for $315,139. They have expended, it is said, more than double that amount, and the total cost will probably be not far from a million dollars. Work was commenced on the shore end of the tunnel, March 17, 1864; and its completion in so short a time is due principally to the skill and energy of the City Engineer, Mr. E. S. Chesbrough, formerly connected with the Cochituate Water Works at Boston.

The shore-end shaft consists of sections of great cast-iron tubing, about 36 feet long and 9 in diameter, let into the earth by simply excavating beneath them, and allowing them to sink as the earth was removed. Having in this way worked through the sand and into the blue clay, which forms the bed of the lake, the shaft was narrowed to 8 feet, and carried down over 40 feet lower, with brick walls a foot thick. This shaft was sunk four feet lower than the lake shaft, causing a descent of two feet per mile in the tunnel to facilitate emptying when required. From the shore end the tunnel extends two miles in a straight line, at right angles to the shore.

At the lake end of the tunnel the greatest engineering difficulty and triumph occurred. Many engineers believed that it would be impossible to make a permanent structure at this point, on account of the violent storms on the lake. It was, however, effected by a huge wooden crib or coffer-dam, built, like a ship, on the shore, launched, and towed to its destined location.

This immense crib was launched July 26, 1865; it is 40 feet 6 inches high, pentagonal, in a circumscribing circle of 98 feet 6 inches in diameter. It is built of logs one foot square, and consists of three walls, at a distance of 11 feet from each other, leaving a central pentagonal space having an inscribed circle of 25 feet, within which is fixed the iron cylinder, 9 feet in diameter, to run from the water line to the tunnel, 64 feet below the surface and 31 feet below the bed of the lake. The crib is very strongly built, containing 750,000 feet of lumber, board measure, and 150 tons of iron bolts, and weighs about 1,800 tons. It was towed to its position, two miles from the shore, on the same day, and the process of sinking began by opening sluices and placing some 600 tons of stone in the bulkheads. The crib will hold 4,500 tons of stone when filled, giving an extra weight of 3,900 tons for steadying against the waves. As built it will stand about seven feet

above the water line, but, when filled, another five feet will be added.

The angles of the crib were armored with iron two and a half inches thick. The three distinct walls or shells, one within another, were each constructed of 12-inch square timber, caulked water-tight like a ship, and all three braced and girded together in every direction, with irons and timbers, to the utmost possible pitch of mechanical strength. Within these spaces were constructed fifteen caulked and water-tight compartments, which were filled with clean rubble stone, after the crib was placed in position. By this means the crib was sunk to the bottom, where it was firmly moored by cables reaching in every direction to huge screws forced ten feet into the bed of the lake. The water in which it was sunk was thirty-five feet deep, leaving five feet of the structure above the surface. This was in June, 1865. The crib had cost $100,000.

The crib stands 12 feet above the water line, giving a maximum area of 1,200 feet which can be exposed at one sweep to the action of the waves, reckoning the resistance as perpendicular. The outside was thoroughly caulked, equal to a first-class vessel, with three threads in each seam, the first and last being what is called "horsed." Over all these there is a layer of lagging, which will keep the caulking in place, and protect the crib proper from the action of the waves. A covered platform or house was built over the crib, enabling the workmen to prosecute the work uninterrupted by rain or wind, and affording a protection for the earth brought up from the excavation, and permitting it to be carried away by scows, whose return cargoes have been bricks for the lining of the tunnel. The top of the cylinder will be covered with a grating to keep out floating logs, fish, &c. A sluice made in the side of the crib will be opened to let in the water, and a lighthouse will be built over all, serving the double purpose of guarding the crib from injury by vessels, and of showing the way to the harbor of Chicago.

The next thing was to sink a water-tight shaft within the well of the crib and into the bottom of the lake some 30 feet further, making 66 feet in all below the surface of the water. Seven great iron cylinders, each nine feet long, nine feet in diameter, two and a half inches thick, and weighing 30,000 pounds, were cast for this purpose. The seven iron cylinders, making the iron part of the shaft, and 63 feet of it in height, were one by one connected by bolts, and lowered to the bottom of the lake within the 30 feet open space in the centre of the crib. In the next to the upper of these cylinders are the gates or valves by which the water will be let in to and shut out from the tunnel. The cylinders were then, after having been brought to exactly the right position, forced downward into the stiff, hard clay of the bottom some 25 feet, the water being wholly excluded.

The water was now pumped out, the top of the shaft was closed as nearly as possible air-tight, and a powerful air-pump, driven by steam, commenced to exhaust the air also. As fast as a vacuum could be created, the atmospheric pressure, added to its own

weight of over 100 tons, forced the huge shaft downward into the bed of the lake with inconceivable force. Thus a depth was reached and secured, at which it became perfectly safe to carry forward the excavation, and complete the shaft to the level at which the tunnel was to begin. The loose rubble-stone is finally to be taken out of the water-tight compartments, one at a time, and they will be re-filled with piers of solid masonry, laid in hydraulic cement, and united above the surface in some manner, so as to present an immovable front on all sides against the force of storms.

Both shafts having been completed, the excavation of the tunnel was commenced from both ends. The work was commenced at the lake end about October, 1865; and the tunnel was finished about Nov. 25, 1866. One-third of the length from the shore end at the rate of about 17 feet a day, or about 3,200 feet, was completed before the commencement of the boring from the lake end. About four-fifths of the tunnel was made from the shore side; the three intermediate cribs and shafts, at first proposed, were omitted, and all the work carried on by the shafts at each end; the floor of the crib at the lake end was made of 12-inch timber instead of plank.

The clear width of the tunnel is five feet, and the clear height five feet two inches, the top and bottom arches being semi-circles. It is lined with brick masonry eight inches thick, in two rings or shells, the bricks being laid lengthwise of the tunnel, with toothing joints. The bottom of the inside surface of the bore at the east end is 66 feet below the water-level, and has a gradual slope towards the shore of two feet per mile, falling four feet in the whole distance, to admit of its being thoroughly emptied in case of repairs, the water being shut off at the crib by means of a gate. The work has been laid in brick eight inches thick all round, well set in cement. The lower half of the bore is constructed in such a manner that the bricks lie against the clay, while in the upper half the bricks are wedged in between the brick and the clay, thus preventing any danger which might result from the tremendous pressure which it was feared might burst in the tunnel.

The work was continued night and day, with but slight interruption, and at all seasons. A narrow railway was laid from the foot of each shaft, as the work progressed, with turn-out chambers for the passage of meeting trains; and small cars, drawn by mules, conveyed the excavated earth to the hoisting apparatus, and brought back at every trip a load of brick and cement. The men worked in gangs of five, at the excavation; the foremost running a drift in the centre of the tunnel, about two and a half feet wide, the second breaking down the sides of the drift, the third trimming up the work to proper shape and size, and the last two loading the earth into the cars. The bricklayers followed closely, only a few feet behind the miners. About 125 men were employed in this work, in three relays, working eight hours each; the only cessation being from 12 o'clock Saturday night, to 12 o'clock Sunday night. A current of fresh air was constantly forced through the tunnel by machinery. It is remarkable that

no serious accident from earth, gas, or water, occurred in the whole course of the work.

The soil has been found to be so uniform that only one leakage of water through the tunnel ever occurred, and that only distilling through a crevice at the rate of a bucketful in five minutes. This occurred in September, 1865. The workmen left in dismay, but soon returned and repaired the crevice. From that time no accidents of any importance have occurred to hinder the progress of the work, with the exception of one or two slight escapes of gas, which resulted in nothing serious. Several stones, varying from the size of an egg upwards, have been met with, but very few in comparison with the great mass of clay. The only fault to be found with the clay was, that it contained too much calcareous matter to make good bricks. The contractors claim that they have lost money on this account. The bricks formed of the clay found in the tunnel would not burn solidly, so that they were obliged to get bricks elsewhere.

The lining of the shore-shaft consists of twelve inches of the best brick and cement, in three shells; about 4,000,000 bricks were used in its construction.

On the 16th of November, 1866, the opposite gangs of workmen were within two feet of each other, and this partition was broke through on the following day in a formal manner by the Board of Public Works. The accuracy of the measurements of the engineer was such, that the two lines of excavation coincided in the centre within nine and one-half inches, and the floors joined with a difference of only one inch.

Water is to be let into the lake-shaft by three gates, on different sides, and at different heights. The lowest is five feet from the bottom of the lake; the next ten feet, and the highest fifteen feet. Flumes through the surrounding masonry, also closed by gates and gratings at their outward ends, will conduct the water to the shaft gates. All the gates can, of course, be opened and closed at pleasure.

The tunnel, as now constructed, will deliver, under a head of two feet, 19,000,000 gallons of water daily; under a head of eight feet, 38,000,000 gallons daily, and under a head of eighteen feet, 57,000,000 gallons daily. The velocities for the above quantities will be one and four-tenths miles per hour, head being two feet; head being eight feet, the velocity will be two and three-tenths miles per hour; and the head being eighteen feet, the velocity will be four and two-tenths miles per hour. By these means it will be competent to supply one million people with fifty-seven gallons each per day, with a head of eighteen feet. With regard to the character of the work, the material met with in the process of excavation has been stiff blue clay throughout, so that the anticipations of the contractors have, in this respect, been fulfilled.

The crib, since it was sunk and loaded, has been thoroughly tested by violent storms, and, during the winter, by the moving fields of ice. It withstood the shocks, both of the ice and the storms, without injury, and the least movement of it, since it was fairly loaded, has not been discovered.

TUNNEL UNDER THE ENGLISH CHANNEL.

Mr. Hawkshaw has been engaged in making trial borings with a view to develop a project for a railway tunnel under the channel between Dover and Calais, and communicating on the English side with the Chatham and Dover Railway, and on the French side with the Northern Railway of France. He proposes to carry on the excavations for the tunnel from both ends, and also from shafts in the channel, at the top of which powerful engines will be erected for pumping and winding up the excavated material, and for supplying motive power to the machinery by which the excavation is effected.

On the other hand, Mr. George Remington is of opinion that a tunnel on the site proposed by Mr. Hawkshaw is impracticable, on account of the difficulty he anticipates in keeping down the water in a chalk excavation of that magnitude. He therefore proposes another line for the tunnel between Dungeness and Cape Grisnez, which, entirely avoiding the chalk, passes through the Wealden formation, consisting chiefly of strong clay. The tunnel would be twenty-six miles in length from shore to shore. On this route in mid-channel, there is an extensive shoal, with only eleven feet of water upon it at low-water spring tides, where Mr. Remington proposes to construct a shaft protected by a breakwater.

CHICAGO RIVER TUNNEL.

A tunnel has recently been commenced at Washington street, on the south branch of the Chicago river. It is to consist of three passage-ways, the centre one to be used by foot-passengers and the two side ways to be used for vehicles. The middle passage will be 15 feet high and about 10 feet wide, each of the outer passage-ways being 11 feet in width by 15 feet at the highest point. The width of the river at Washington Street is about 180 feet, while the whole length of the tunnel, after providing for a suitable inclined plane at each entrance, will be about 945 feet. The floor of the tunnel at the centre of the river will be about 32 feet below low-water mark.

The tunnel is to be constructed by means of coffer-dams, which are to be placed, with their protections, up and down the river, within a space, north and south, of not over 150 feet, and, east and west, of not over 100 feet, so as to have a space of nearly 50 feet for the passage of vessels entirely unobstructed. Upon the completion of the work, such portions of the dams as may remain will be entirely removed, so as to leave the river as unobstructed as at present. The tunnel proper is to be formed of the most perfect brick and stone masonry, backed with concrete, while the floor of roadways will be neatly paved with Nicholson pavement. The work is to be completed in March, 1868.

Should this latter work prove a success, we may look for the general adoption of the tunnel instead of the bridge plan at all our river crossings; and, as a consequence, the absolute freedom

of the river to sailing craft of all descriptions, thus avoiding the almost interminable delays now caused by the constant swinging of the various bridges during the season of navigation, as well as the many accidents which are sure to result from our present bridge system.

The longest tunnel in England is the Box Tunnel on the Great Western Railway, which is 9,680 feet long, 39 feet high, and 35 feet wide.

SAND-PATCH TUNNEL.

The miners working in the middle section of the Sand-Patch Tunnel, on the Pittsburg and Connellsville Railroad, have met, thus piercing once more the great mountain barrier between the Ohio valley and the sea-board. The Sand-Patch Tunnel is 4,750 feet long, or 1,000 feet longer than the Alleghany-Mountain Tunnel of the Pennsylvania Railroad. It was commenced some ten years ago, is to accommodate a double track of rails all through, being 22 feet wide, and 19 feet high. The greater portion of it goes through solid red sand-stone, not requiring any brick arching for that distance. The grade of the tunnel is 2,200 feet above the level of the sea, or 1,500 feet higher than low-water mark of the Ohio river at Pittsburg.

THE MONT-CENIS TUNNEL.

It is estimated that the number of holes which have to be drilled by the rock-boring machines in the Mont-Cenis Tunnel, before that work is completed, is about 1,600,000. The total depth of all these holes when bored will amount to about 4,265,-890 feet, which is 105 times the length of the tunnel. Nearly 13,-000,000,000 blows will be struck by the perforators, to do this work. The entrance to the tunnel, on the French side, is 3,946 feet above the level of the sea, and its termination, on the Italian side, 4,380 feet, so that the actual difference of level between the two extremities is about 434 feet.

The total length of the Mont-Cenis Tunnel is 12,220 metres; of this, 7,977 remain to be made. Having been begun in 1858, and with new methods and energy in 1863, 4,423.4 metres were finished on the first of April, 1865; of which, 1,646 metres were accomplished by the old methods of tunnelling, and 2,777.4 by the new mechanical methods, since the commencement, of 1863 — 802 metres in 1863; 1,088 in 1864; and 337.4 in the first quarter of 1865. The rate of progress in 1862 was 2.02 metres per day; in 1864, 2.92 metres, and in 1865, thus far, 3.75. At the last rate, it will take 5 2-3 years to complete the tunnel.

Air is compressed by water-power outside, and is conveyed by pipes into the excavation, where it gives motion to the chisels that perforate the rock, forming cavities for the gunpowder used in blasting. Small perforators travel on a carriage, each of them being a kind of horizontal air-pressure engine, the prolonged piston-rod of which carries a jumper, that makes 250 strokes a minute. The excess of pressure on each jumper, above that of the air-spring which brings it back, is 216 lbs., thus bringing a very considerable power into action.

THE FRENCH CANAL AT SUEZ.

It is announced that in 1867 the long-projected canal through the Isthmus of Suez, will be opened to the world. In this great enterprise, the French have once more shown their extraordinary control of persons of totally opposite characters and habits of life, and have, moreover, exhibited the business faculty in a degree rarely shown by other than Englishmen. There are now working at the canal nearly 19,000 men, of whom 8,000 are Europeans, and the remainder Arabs, Egyptians, or Syrians. The crews of the dredging-machines are often composed of Frenchmen, Italians, Greeks, Germans, Egyptians, and Maltese; and we are assured that they are in no way inferior to the more homogeneous crews which are seen at home. The Orientals even exhibit a zeal and ardor which almost equal the activity of Frenchmen. The arrangements for the housing, feeding, and sanitary welfare of the workmen are, seemingly, very complete. There is free trade in provisions, and 1,490 traders have established along the line of works, hotels, canteens, warehouses, and shops, where almost everything can be obtained. The medical, postal, and telegraphic services are under the control of the company. At great expense, a water supply has been obtained, which yields 2,000 cubic metres per day. The district is destitute of water-courses, and this arrangement was, therefore, of the highest importance. By these means, cholera and other maladies have been warded off. From the measures taken by M. de Lesseps and his colleagues, for the comfort and health of the workmen, we might learn a lesson. In India, China, and the colonies, we have army "stations," which are regularly occupied during certain seasons of the year, and which are yet without proper house-room and pure water.

But beyond these things, the mechanical contrivances which have been invented, and are now used, for the several different kinds of work, are worth consideration. Conspicuous among them are the dredging-machines. To cut a channel through a certain piece of land, the plan adopted has been to dig by hand until sufficient depth and width has been secured to float a dredging-barge, when the water has been let in, and the machine set in motion. Instead of emptying the mud into another barge, to be taken out to sea and there discharged, each dredge has affixed to it a long spout, the upper end of which begins on the dredge itself, as high as possible, where it receives the earth raised by the buckets. At the same time, pumps worked by the steam-engine of the dredge raise a torrent of water which carries the earth off beyond the bank, and spreads it over a wide surface. In this country, where we are just now about to reverse our system, and keep our rivers clear instead of filling them with deposits, a modification of this machine would be of great service. By its means we might at once deepen and clear the beds of our rivers, and add materially to the fertility of the adjacent fields. Few things are more fertilizing than what is called "warp," and by the means thus pointed out, this could be obtained artificially.

In many places in England, a plan not unlike that by which the valley of the Nile is made fertile, is carried out. In Yorkshire, for example, it is a regular practice to open the banks of the Dutch river, and allow its turbid waters, which contain much soil in suspension, to spread over the fields. When the gap is closed, and the water drawn off, a rich alluvial mud remains, on which splendid crops are raised. The system of opening the banks of the river is, however, awkward and expensive. The Suez canal-dredge does away with its necessity, and applies scientifically what is now obtained by a very clumsy system. — *London Star.*

The Malta "Observer," of a late date, says: "By reliable information, recently received, we learn that the works of the Isthmus of Suez Canal are being very actively carried forward by M. de Lesseps. An average depth of from seven to nine feet has been obtained from Port Said, along the salt-water canal; and the rest of the distance to Suez is traversed temporarily by a fresh-water one about seven feet deep, connected with the other by means of locks and powerful pumps. As far as sixty stations the full width of the proposed ship-canal has been excavated to sixty metres; but from that point to the seventy-fifth station and Ismalia, the width is incomplete. All that has been done is done well, and reflects the highest credit on the science, skill, and persevering energy of the French engineers. The real difficulties of dredging in a constantly dissolving sand are now commencing; but well informed persons entertain but little doubt that these and all others may be overcome by time and money."

FRITH OF FORTH BRIDGE.

Parliamentary sanction has been obtained for a bridge over the Frith of Forth, of a magnitude which gives it great scientific interest. It is to form part a of connecting link between the North British and Edinburgh and Glasgow Railways. Its total length will be 11,755 feet, and it will be made up of the following spans, commencing from the south shore: First, fourteen openings of 100 feet span, increasing in height from 65 to 77 feet above high-water mark; then six openings of 150 feet span, varying from 71 to 79 feet above high-water level; and then six openings of 175 feet span, of which the height above high-water level varies from 76 to 83 feet. These are succeeded by fifteen openings of 200 feet span, and height increasing from 80 to 105 feet. Then come the four great openings of 500 feet span, which are placed at a clear height of 125 feet above high-water spring tides. The height of the bridge then decreases, the large spans being followed by two openings of 200 feet, varying in height from 105 to 100 feet above high water; then four spans of 175 feet, decreasing from 102 to 96 feet in height; then four openings of 150 feet span, varying in height from 95 to 91 feet; and, lastly, seven openings of 100 feet span, 97 to 92 feet in height. The piers occupy 1,005 feet in aggregate width. The main girders are to be on the lattice principle, built on shore, floated to their position, and raised by hydraulic power. The total cost is estimated at £476,543. — *Engineering, Jan. 5,* 1866.

WASHINGTON AQUEDUCT.

At a meeting held December 6, 1866, Mr. Edward C. Pickering called the attention of the Massachusetts Institute of Technology to one of the greatest of American engineering works, and, at the same time, one of the least known, viz., the aqueduct by which the city of Washington is supplied with water.

The plan accepted by Congress was to erect a dam across the great falls of the Potomac, conducting the water about thirteen miles through two reservoirs to the city. Gen. Meigs, who had the work in charge, instead of reports, prepared photographs of the working drawings and of the aqueduct itself; a set of these rare photographs he exhibited and explained to the Institute. The supply thus obtained for the city of Washington is 67,000,000 gallons daily, twice as much as the Croton, and five and a half times as much as the Cochituate supply. The greatest engineering work in the Cabin John branch is the bridge over Cabin John Creek, which has one stone arch with a span of 220 feet, making the largest arch now in existence; the Chester arch being only 200 feet, London Bridge 152, Neuilly 128, and the Rialto 99 feet. When the centre scaffolding was removed the arch did not settle, the key-stone having been set in winter and the centre struck in summer. Other great arches have settled more or less, according to the excellence of the workmanship of the arch and centre.

From the distributing reservoir the water is conveyed in two 30-inch pipes. There were two streams to be crossed, College Branch and Rock Creeks. In spanning these creeks the structure is remarkable, not only for size, but for the ingenious principle of construction. Instead of building a bridge and laying pipes on it, the pipes themselves were cast in the form of an arch, and constitute the bridge. The Rock Creek bridge has a span of 200 feet, with two 48-inch pipes; the College Branch bridge has a span of 120 feet, with two 30-inch pipes. The arch is so strong over the Rock Creek that a roadway is placed upon it, continuing Pennsylvania Avenue to Georgetown. The pipes were at first lined with wood. The diurnal rise and fall of the bridge is about two inches; this constant motion produced slight leakage from droppings; the wooden lining was then taken out, as it was shown there was no danger of freezing, and now there is no leakage, the pipes remaining at the temperature of the water.

It was commenced in 1853 and finished in 1863.

SUSPENSION BRIDGE AT CINCINNATI, OHIO.

Another great triumph of American engineering is the suspension bridge over the Ohio River at Cincinnati, from Front Street, in that city, to Second Street, Covington, Ky. It is said to be the longest single-span bridge in the world. Its cost was about $2,000,000. It is strong, ornamental, and affords an easy road of communication between the States. Railroad tracks are to be laid over its span. The following are its dimensions, &c.:

Length of main span from centre to centre of towers, 1,057 feet.
Length of each land span, 281 feet.
Total length of bridge, including approaches from Front Street in Cincinnati and Second Street in Covington, 2,252 feet.
Height of towers from foundation, without turrets, 200 feet.
Height of turrets, 30 feet.
Height of bridge above low water, 100 feet.
Width of bridge in the clear, 36 feet.
Number of cables, 2.
Diameter of cables, 12¼ inches.
Amount of wire in the cables, 1,000,000 pounds.
Strength of the structure, 16,800 tons.
Deflection of cables, 88 feet.
Masonry in each tower, 32,000 perches.
Masonry in each anchorage, 13,000 perches.
Masonry, total amount, 90,000 perches.
Towers at base, 86 by 52 feet.
Towers at top, 74 by 40 feet.
Strands in each cable, 7.
Wires in each strand, 740.
Wires in cables, total, 10,360.
Weight of wire, 500 tons.
Feet of lumber, 500,000.

GREAT VIADUCTS.

At a meeting of the Society of Engineers, in January, 1866, a paper was read by Mr. W. H. Mills, on the Craigellachie Viaduct.

This viaduct was constructed for the purpose of carrying the Morayshire Railway over the River Spey, at Craigellachie, Banffshire, the engineers being Mr. Samuel (M. Inst. C. E.) and the author. It consisted of three spans of 57 feet each on the north bank, and one span of 200 feet over the main channel of the river; ordinary boiler-plate girders constituting the former, and the latter being of wrought-iron on the lattice principle. The piers and abutments were of solid ashlar masonry, and the works were arranged for a single line of railway. It appeared that the excavation for the foundations was commenced in May, 1862, and that the viaduct was opened for public traffic in July, 1863. The total cost had amounted to £12,199, or equal to £29 10s. per lineal foot.

A paper was also read at the same meeting by Mr. Ridley, giving some details concerning the Grand River Viaduct, Mauritius Railway.

It was stated that the length of this viaduct, from abutment to abutment, was 620 feet, and that this distance was divided into five openings of 116 feet each in the clear. The height from the level of the rails to the surface of the water was 129 feet 9 inches. Each pier was composed of two cast-iron cylinders, each ten feet in diameter, resting upon masonry foundations, and filled with concrete; the works being for a single line of railway.

GREAT BRIDGES.

The Victoria Bridge over the St. Lawrence, at Montreal, has a total length of one and three-quarters miles, and a length of iron tubing of one and one-quarter miles, with 25 spans, one of 330

feet and the rest of 242 feet, with a headway of 60 feet. The Britannia Bridge over the Menai Straits is 1,487 feet long without the abutments, with two spans of 230 feet each, one of 458 feet 8 inches, and one of 459 feet; and the Saltash Bridge 468 feet. The Forth Bridge has a length of 10,550 feet; and the Severn Bridge nearly 12,000 feet. The bridge of the Hartford, Springfield and New Haven Railroad, over the Connecticut, at Warehouse Point, replaces a wooden structure on stone piers, and was built on the old piers with the addition of several new ones in the same line, so that the present structure occupies the exact site of the former one; and during the seven months of its construction no delay of trains was caused by the work. This is remarkable when the magnitude of the work is considered. The bridge is 1,524½ feet in length, composed of 624 tons of wrought-iron, the flooring only being of wood. In its construction, 175,000, rivets were used. The cost was $264,784.63, and it is capable of bearing a strain of two and a half tons to the foot. The iron-work was made in England, by Fairbairn & Co. of Manchester, and the London Engineering and Iron Ship-Building Company. The plans and designs were by James Laurie, Civil Engineer, of Hartford, Conn. — *Scientific American.*

STEEL BRIDGES.

At a late meeting of the Literary and Philosophical Society, Mr. S. B. Worthington, C. E., stated that he had lately constructed a swing bridge for carrying a railway over the Sankey Canal, in which the girders were made of Bessemer steel plate. The object of using steel instead of wrought-iron was to reduce the weight of the girders; these are four in number, about 56 feet long, with bearings varying from 30 to 40 feet, and 2 feet deep. They were manufactured from steel tubes made by the Bolton Steel and Iron Company; and were tested with loads of a ton to the foot, or more than double the weight which they could possibly be called upon to bear. The deflection varied from one-half to one inch, according to the length of the girder, and there was no permanent set on removal of the testing load. The plates used varied from one-quarter to seven-sixteenths of an inch in thickness; and the average tensile strength of a considerable number of plates tested was upwards of 36 tons to a square inch. The weight of the girders was about five-eighths of the weight which they would have been if wrought-iron had been used.

CONCRETE BLOCKS FOR BUILDING.

An ingenious application of the well-known process of moulding blocks of concrete for building purposes was patented some time back. The inventor, a Mr. Tall, proposes to erect walls, houses, and other structures, by literally casting them of concrete, in the place they are intended to occupy. An ordinary concrete foundation is first laid, and upon the foundation horizontal frames, constructed of boards lined with zinc or other metal, are set up on edge, so as to form a kind of trough for receiving the concrete.

By the insertion of suitable cores, holes for the insertion of the joists, or for other purposes, may be moulded in the concrete as the work proceeds.

LIME CONCRETE IN CONSTRUCTIONS.

Mr. F. Ingle communicated to the British Association, in 1866, a paper in which he pointed out what he considered a radical defect of concrete formed from lime as ordinarily used, viz., that by the action of fire it becomes reconverted into lime, which, when the water from the engines is brought to bear upon it, expands greatly, and forces out the walls, to the destruction of the building. He advocated the use of a concrete formed from gypsum, which is not liable to this defect. The gypsum, which is of a coarse and inexpensive character, is formed into plaster of Paris by roasting, and mixed with a peculiar kind of clay found in connection with the beds of gypsum.

HYDRAULIC CEMENTS.

M. Frémy communicated, in May, 1865, an important paper on this subject to the French Academy of Sciences. Vicat assumed the formation of a double-silicate of alumina and lime, which, by absorbing water, was the cause of the setting of hydraulic cements, and this view seemed to be confirmed by finding in the calcined cements a silicate which formed a gelatinous precipitate with an acid, which silicate did not pre-exist in the stone before calcination. MM. Rivot and Chatonay suggested that the calcination of the argillaceous limestone gave rise to an aluminate of lime having the formula $Al^2 O^3 3 Ca O$, and to a silicate of lime represented by $Si O^3 3 Ca O$, which salts brought into contact with water form hydrates, each with six equivalents of water, and thus cause the setting.

The result of the experiments of M. Frémy is, that the setting of cements is due to two different chemical actions: first, to the hydration of the aluminates of lime; and secondly, to a puzzuolanic action, in which the hydrates of lime combine with the silicates of lime and alumina. He found that alumina is even a better flux for lime than silica, and he suggests that the very basic compounds of these two substances — those, for instance, containing from 80 to 90 per cent. of lime — may be useful in the iron furnace, owing to their disposition to absorb sulphur and phosphorus, and thus free the metal from these noxious impurities. He also finds that no substance is capable of acting as a puzzuolana except the simple or double silicates of lime, containing only from 30 to 40 per cent. of silica, and sufficiently basic to form a gelatinous precipitate with acid.

INSOLUBLE SILICATE.

M. Ch. Guerin called the attention of the French Academy to a new method of obtaining, by a cold process, a silicate completely insoluble, which can be applied either as an external coating, as in the case of glass or iron, or made to penetrate through the interior of the substance, as for the preservation of wood and

other vegetable matters. The process is very simple: a thin coating of slaked lime made into paste with water, or whitewash, is laid on the object to be silicatized, and, when this has been allowed to dry, silicate of potash is applied over the coating; the effect, it is asserted, being that all the portions touched by the solution of potash become completely insoluble, and of very great adherence. In order to obtain an insoluble silicate in the interior of a substance, all that is necessary is to impregnate it by immersing it in whitewash or lime-water, and, when it is dry, to steep it in a solution of the silicate of potash.

By this means it is proposed to prevent the decomposition of vegetable substances by petrifying them; also, to protect porous building-stones and brick against air and damp; iron, by a coating of paper, pulp, or other finely-divided woody matter, mixed with slaked lime.

Again, letters, characters, or any other device, can be traced with the silicate on any surface spread with lime; and those portions touched by the silicate will alone adhere and become insoluble. Or, if they be traced with a solution of gum arabic, and the whole be washed over with the silicate, the parts protected by the gum can be washed off, the rest remaining in relief, as the letters, etc., do in the first place.

The process seems to be substantially the same as the English process known as Ransome's. — *Scientific American.*

A NEW CEMENT.

A late number of the "London Engineer" announces a new cement of great value, which is introduced under the euphonious title, "The zopissa iron cement," which, it is claimed, is capable of joining any two solid substances, however dissimilar. Wood, brick, iron, stone, or glass, can be inseparably united with equal facility. A series of experiments, witnessed by the "Engineer," gave the following results: —

Plates of glass were firmly joined, edge to edge; ordinary bottles stuck upon the wall resisted all attempts at separation, till the stone yielded. Champagne bottles, cemented bottom to bottom, sustained a weight of 250 pounds. Two bricks remained joined under a tension of 325 pounds, till the brick itself fractured, but the cement remained firm. Brick-work cemented with this has the solidity of a granite slab.

With paper treated with this preparation in solution, the inventor has made air and water-tight tubes, ammunition cases, coffins, and even constructed a house, one story and a half in height, perfectly wind and water tight, which he has now on exhibition.

Of the constitution of this cement, or the expense of manufacturing it, the "Engineer" makes no intimation.

HARD HYDRAULIC CEMENT.

The following receipt is given for a cement, which, it is said, has been used with great success in covering terraces, lining basins, soldering stones, etc., and everywhere resists the filtration of

water; it is so hard that it scratches iron. It is formed of ninety-three parts of well-burned brick, and seven parts of litharge, made plastic with linseed oil. The brick and litharge are pulverized; the latter must always be reduced to a very fine powder; they are mixed together, and enough of linseed oil added. It is then applied in the manner of plaster, the body that is to be covered being previously wet with a sponge. This precaution is indispensable, otherwise the oil would filter through the body and prevent the mastic from acquiring the desired hardness. When it is extended over a large surface, it sometimes happens to have flaws in it, which must be filled up with a fresh quantity of the cement. In three or four days it becomes firm. If its advantages have not been overrated it must be a very excellent cement for making the joints of aquaria water-tight. — *Druggist's Circular*, 1866.

At the meeting of the Paris Academy of the 4th of December, 1865, H. St. Claire Deville showed that magnesia, kept for some weeks in pure water, sealed up so that the air is excluded, combines with water, and forms a hard and compact, crystalline, translucent substance, consisting of magnesia 68.3, water 31.7, or a simple hydrate of magnesia. He has made copies of medals, like those of plaster, from magnesia thus hardened under water. Balard's magnesia, calcined at a red heat, he says, has hydraulic qualities which are manifested with a rapidity that is admirable, though, when calcined at a white heat, this property is almost entirely lost. A mixture of powdered chalk, or marble and magnesia in equal parts, furnishes with water a paste which is slightly plastic, but which, after being some time in water, affords products of very great solidity; and he proposes to make busts of artificial marble from the mixture. Plaster mixed with the magnesia diminishes the hydraulic properties. On calcining dolomites rich in magnesia, the same rule as to hydraulic properties is remarked in regard to temperature, the higher the heat the less the hydraulic properties. He thus believes that this substance, now so cheaply and abundantly furnished by M. Balard's processes, will come into extensive use in subaqueous structures. — *Les Mondes, Dec.* 7, 1865.

A cement, capable of uniting into a solid mass stones, pebbles, &c., so as to form artificial pudding-stone, conglomerates, &c., of extraordinary strength and tenacity, impervious to moisture, and capable of being moulded into statues, bas reliefs, &c., may be made by finely triturating iron sponge, and mixing it with sand which has been moistened with slightly acidulated water. The iron is oxidized at the expense of the water, and the silex forms with the oxide silicate of iron, which possesses a very great tenacity, and is not affected by atmospheric changes, nor even by acid or alkaline liquids at a boiling temperature. — *Intellectual Observer, Feb.*, 1866.

CEMENT WITH A GYPSUM BASIS.

The plaster is first burned in the usual way, in an appropriate furnace, to drive off the water; after this it is broken into small

fragments, which are immersed in a solution of alkaline silicate, containing an alkaline carbonate. The solution which answers best is composed of silicate of potash, containing a sufficient number of equivalents of carbonate of potash to avoid the precipitation of the silica, in the following proportions: 0.880 kilog. (1.94 lbs.) of silicate of potash containing 0.255 kilog. (.56 lb.) of carbonate of potash, in 4.54 litres (a gallon) of water, a solution having a specific gravity of 1,200, but which may vary according to the use for which the cement is intended. As, for example, it can be employed of the strength above indicated in a great many cases where the best quality is required; and, if an ordinary cement is only necessary, it can be diluted with two parts of water to one of the solution. If a cement be required to harden slowly, sulphate of potash may be added to the carbonate, so that the indurating action of the silica upon the plaster may thus be varied at pleasure. After having left the plaster steeped in the solution for twenty-four hours or so, it is taken out and left to drain in a compact mass, in order that the diffusion of the solution through the plaster may take place more effectually; the cement is then taken back to the furnace, and reheated to 150° or 250° C. (302° to 482° Fahr.) to drive off all the water, after which it is ground to powder, and can be colored to any desired hue by mixing with a pigment.—*London Builder*, *No.* 1210.

NEW MORTAR.

The mortar used by the Romans has, in the course of ages, set so strongly as to be equal in hardness to the stones it was used to cement, and its analysis shows that this is due to the abundant formation of silicate of lime throughout the mass. Modern mortar, on the contrary, usually hardens slowly, cracks while hardening, has but little adhesion, and its useful effect is simply as a bed for the proper support of the stone or brick upon its whole surface, and the consequent distribution of the pressures properly over the sustaining masses. Analysis shows little or no formation of silicates, and the carbonate of the quicklime (for it absorbs carbonic acid itself very slowly) is soluble in the rain to which it is exposed, and rapidly dissolves out. Dr. Artus proposes a method of preparation by which the process of silication is much favored; by which, it is said, a mortar may be prepared which becomes as hard as cement, does not crack in setting, and may be used as a hydraulic cement under water. This process is as follows: Take good slacked lime and mix it with the utmost care with finely sifted sand; mix the sand thus prepared with finely powdered quicklime, and stir the mixture thoroughly; during the process the mass heats, and may then be employed as mortar. Of course, the mixture must be made just as it is to be used. One part of good slacked lime was mixed with three parts of sand, and to this was added three-fourths of its weight of finely powdered quicklime. The mortar thus made was used in a foundation wall, and in four days had become so hard that a piece of sharp iron would not attack it. In two months it had become as hard as the stones of the wall.

It might be worth while to try this for laying the bricks of our chimneys, which are so rapidly destroyed and rendered dangerous by the gases from burning anthracite. — *Journal of the Franklin Institute, July,* 1866.

S. P. RUGGLES'S DYNAMOMETER.

At the meeting of the American Academy of Arts and Sciences, held January 9, 1866, Prof. Charles W. Eliot exhibited and described a new kind of dynamometer, invented by Mr. S. P. Ruggles of Boston:

"This new and admirable invention accomplishes two objects; first, it measures the exact amount of power which is being consumed in driving a single machine, or any number of machines, at any instant of time, indicating every change in the force required, as the work done by the machines varies from instant to instant; secondly, the apparatus adds up and registers the total amount of power which has been used by any machine, or set of machines, during a day, a week, a month, or any desired time. The apparatus may be thus described. The pulley from which the power is taken, is attached to the shaft by the intervention of a spiral spring. One end of this spring is secured to the shaft, and the other end to the hub of the pulley. The lateral motion of the pulley upon the shaft is prevented by a collar on either side of the pulley. On the inside of the hub is cut a screw of about three-inch pitch, that is, a screw which makes a complete turn within a distance of about three inches measured on the axis of the hub. A rectangular slot is cut out of that part of the shaft which lies within the hub of the pulley, and in this slot slips backwards or forwards a piece of metal which precisely fits the slot. From each side of this small piece of metal, there projects beyond the surface of the shaft a small portion of the male screw which exactly fits into the screw cut in the interior of the hub of the pulley. If there be no resistance at all to the motion of the pulley, shaft, spring, and pulley will all start together, and revolve together. But if a resistance be offered to the motion of the pulley, the shaft, and with it the piece of metal which slips in the slot, will start first, and the pulley will move only when the strain caused by the twisting of the spring is sufficient to overcome the resistance applied to the circumference of the pulley. But if the piece of metal in the slot begins to turn while the hub of the pulley is stationary, the piece must move laterally within the slot, being forced by the screw. If the pulley starts a quarter of a turn later than the shaft, the piece will move laterally three-quarters of an inch; if the pulley starts a half a turn later than the shaft, the piece will move laterally an inch and a half. The lateral motion of the piece in the slot is proportional to the retardation of the pulley, and this retardation is proportional to the strain upon the belt which passes over the pulley, and conveys the power to be used. To the movable piece in the slot is connected a small round rod, which runs out through the centre of the main shaft and projects some little distance beyond it. On the end of this rod is a circular rack of teeth, in which plays a pinion, on whose

shaft is a hand moving over a dial-plate. By applying strains, measured by standard scales, to the belt which passes over the pulley, — as a strain of ten pounds, fifty pounds, one hundred pounds, — it is easy to graduate the dial-plate into pounds, so that the number of pounds of strain upon the belt may be read off at any instant by a mere inspection of the dial. The mode of operation of this part of the apparatus is then as follows: When no power is being conveyed from the pulley, shaft and pulley start simultaneously; there is no lateral motion of the piece within the slot and its connected rod, and the hand on the dial points to zero. But the moment that power begins to be expended in driving the machinery, the strain upon the belt will be first felt by the spring which connects the pulley to the main shaft, and the spring will yield in proportion to the strain; the effect is to let the shaft make a small part of a revolution in the hub of the pulley before the pulley begins to turn and keep pace with the shaft; the rod within the end of the shaft is thus drawn in a little, the hand moves over the dial-plate, and points to the exact number of pounds of power which the belt is conveying from the pulley at the instant of observation.

The registering of the total amount of power delivered from the pulley is effected by means of two small belts running over the round rod, which projects beyond the end of the main shaft and carries the index-hand above described. These two small belts communicate the motion of the shaft to two parallel and equal wheels, one of which bears a dial-plate, and the other an index-hand which moves over the dial-plate. When there is no strain upon the main belt going over the pulley, the two wheels revolve at the same rate, neither gaining upon the other, and the hand remains constantly over the same figure on the dial-plate; but when a strain is put upon the belt, and the round rod moves laterally, as above described, the lateral motion brings a conical enlargement of the rod under the little belt which moves the wheel bearing the dial. The dial-wheel now goes faster than the wheel carrying the hand, and begins to count up the power used. The greater the lateral motion of the rod, or, in other words, the greater the power transmitted to the working-machines, the larger the diameter of the cone which comes under the belt of the dial-wheel, and the greater the gain of the dial upon the hand. The wheels of both dial and hand are constantly revolving in the direction opposite to that of the motion of the hands of a watch. The belt of the hand-wheel runs always upon the rod where its diameter is constant, and as the rod moves laterally under the little belts, guides are necessary to keep the belts themselves from moving laterally also. The proportions of the cones on the rod and of the two wheels which carry the dial and the hand, can be so adjusted as to make a difference of one complete revolution between the motions of the hands and of the dial, indicating a delivery of ten thousand foot-pounds, or of ten million, or of any other convenient number, and by a system of gearing analogous to that used in gas-metres, any desired amount of power could be consecutively registered. It is obvious that the

registering apparatus takes account of both the strain and the speed, while the simple index first described measures only the strain.

This instrument is at once elegant in design, simple and therefore cheap in its construction, easily verified and proved at any moment when in operation, and of very easy application to any machine, or set of machines, driven by hired power, whether the power used be constant or variable in amount. The instrument admits of a great variety of forms; the one described above is meant for the end of a shaft; another form is so arranged as to be attached at any part of a running shaft, while in the proportions and dimensions of the several parts there would be the same variety as in common scales, which are large or small, coarse or fine, according as they are meant to weigh coal or pills, hay or coin. The instrument meets a pressing want. Tea and sugar are sold by the pound, gas by the thousand feet, cloth by the yard, but steam-power and steam and air engines are sold by guesswork, or by rough and uncertain rules, on whose application buyer and seller can seldom agree.

Hereafter steam-power can be sold by the thousand or million foot-pounds.

Mr. Ruggles does not patent his valuable invention.

RUGGLES'S SHAFT-COUPLING.

There are some mechanical powers, which, because of not being of universal or general application, are seldom used and recognized, but which are of a most important and valuable character. Such is the differential screw, which is rarely used, but which, in certain instances, is the strongest grip known in mechanics. This has been applied in the above improvement very effectively.

It is a differential screw-bolt having two threads, that on the upper portion being ten to the inch, and that on the lower part nine to the inch. The head of the bolt is six-sided, and is flush with the surface of the box. It is seated in a circular recess, which is large enough to receive on the end a cylindrical or socket-wrench. Threads corresponding with those on the two portions of the bolt are tapped in the boxes made to fit the shaft.

The above is sufficient to explain to any practical man the operation of this device. It will readily be seen that a few turns of the screw will be sufficient to clamp the shaft-ends in a grip, the power of which is limited only by the strength of the material. Two steady-pins are inserted in the shaft, and project into holes drilled into the coupling-boxes, to provide against negligence in setting up the screw, thereby allowing the shaft to turn.

This is evidently a valuable and efficient coupling. It presents no nuts or bolt-heads to catch belts or clothing, obviates the necessity of keys and splining, cannot get out of order, and presents a neat appearance, when turned and polished looking nearly like the enlargement of the shaft.

This invention was patented April 24, 1866, by S. P. Ruggles, Boston, Mass. — *Scientific American.*

WICKERSHAM'S NAIL MACHINE.

Before the year 1807, nail-making was a very slow and laborious process, each nail being cut from the bar by shears, and then screwed into a vice where the head was struck on by a hammer.

About this time, Mr. Jesse Reed, of Massachusetts, invented a machine by which the cutting and heading of the nails were performed by one continuous operation in the same machine. This Reed Machine, though it cut but one nail at a time, has, with but slight alteration, been the only nail-machine in use up to the present date.

By a reasonable estimate, Mr. Reed, by his machine, reduced the cost of cutting and heading nails to one-tenth that of the process used before his invention, and those who availed themselves of rights under his patent have thereby realized large fortunes.

The machine now brought to public notice by Mr. William Wickersham cuts the nail with head ready formed at less than one-tenth of the cost by the machines now in use, and at the same time it produces a nail which, from being pointed like a chisel, and gradually tapered its whole length, is much better for use, being more easily driven and holding much more firmly, as it breaks the grain of the wood so little that it clings tightly and firmly the whole length of the nail.

The universal plan has hitherto been to make the plate from which the nails are cut wide enough for the length of the nail, and then commence cutting from one end, and continuing the operation until it is all cut into nails, the machine cutting only one at a time.

In the Wickersham Machine a sheet of metal from 20 to 25 inches square is placed, and a series of nails cut from its edge at each stroke of the knives. To do this, there are two series of cutters, viz., bed and moving cutters, so arranged that by shifting the nail-sheet laterally the distance equal to the length of two nails, each time a series of nails is cut, the nails being alternately reversed as to heads and points. The motions of the machine are reduced to their greatest simplicity, there being only three motions, viz., the crank-motion of the cutter jaw, the cam-motion for shifting the nail-plate, and the feed-motion which moves the nail-sheet towards the cutters each time it is shifted and a series of nails cut.

In cutting half-inch patent brads or shoe-nails from a twenty-inch plate, there is a series of 40 nails cut at each stroke of the knives, or 160 per second, the machine driving the knives four times per second; of patent brads from three-eighths to two inches long, and shoe-nails of all sizes, one machine will cut 3,600 lbs. per day. Of the larger size nails, say six to twelve-penny nails, one machine will cut 5,000 lbs., and of ship-spikes, of one quarter to three-quarter lbs. each, one machine will cut 25,000 lbs. per day of ten hours.

From the best authority it appears that there are 3,000,000 kegs of nails made annually in the United States; of these three-

tenths are finishing nails; besides, there are 200 to 300 tons of shoe-nails, and about 1,500 tons of ship-spikes and nails made of yellow metal.

ON THE UTILIZATION OF PEAT AS FUEL.

An invention of considerable practical importance for the condensing and moulding of peat for use as fuel, has recently been brought to public notice by Mr. T. H. Leavitt. In a pamphlet compiled by him, and published in Boston in 1866, the whole subject of peat fuel is thoroughly treated, showing its economy as a substitute for wood and coal, especially where fuel is required in large quantities.

The discoveries of the more important uses of peat are recent, though its use, in an imperfectly prepared form, has for a long time been known in various parts of Europe and in this country. It is found to contain a rich supply of the carboniferous oil of which our common illuminating gas is made, and is pronounced equal in that respect, pound for pound, to gas coal. It also produces rosin and some paraffin. Its analysis shows but five per cent. of ashes, and 55 of carbon.

The experiments made last year on some of the railroads in Great Britain prove very conclusively that peat can be advantageously substituted for coal on the locomotive. That it is also actually equal, if not really superior, to the best charcoal itself for smelting iron ore and for puddling iron, has been demonstrated with equal certainty. The iron thus produced is tougher, finer, more malleable, freer from flaws, than any other. By this use of peat, iron from English mines of admitted inferiority to the famous Old Hill mine in Salisbury, Connecticut, and the equally celebrated Swedish charcoal iron, has been produced of a quality equal to either.

In all cases where it has been properly prepared, it is found to burn equally well in a coal-stove, wood-stove, or fire-place, and to make a very pleasant fire, with more flame than coal makes; and it leaves no cinders. Its freedom from sulphur renders it far less destructive than anthracite coal to the iron bars of the grate. A stove lasts much longer with peat. This freedom from sulphur, a point of the first importance in the selection of fuel for the reduction of iron ores, is also a weighty consideration with the railroad men, whose experiences with the destructible action of anthracite on their engines have made them shy of that fuel.

It comes in good time. Coal has been unreasonably expensive; and a good article of peat, that can be used in the stove, the grate, the old "fire-place," or under a steam boiler, at prices far below those for coal, after making every allowance for the relative capacity of the two articles, will be likely to be generally used. Peat keeps a live coal till all is consumed, and is said to be superior for cooking. Its importance in mechanic arts is likely to be extensive. It already finds favor for the process of melting gold; it is pronounced a success in working steel; while its use in annealing is proved by the superiority of the wire made by means of peat.

The paper read last year before the British Association by Civil Engineer Clark, of London, contains important facts relative to peat. A large establishment is engaged in making it in England, and its trial on two of the British railways proved that it maintained a higher and better head of steam than coal did, that better time was made, and that, pound for pound, it was a saving both of time and money to use peat in locomotives.

The machine of which we have spoken may be worked by steam or other power. It receives the crude peat just as it is taken from the bog, condenses it, and in a very few minutes delivers it in the form of bricks, which may then be exposed in the open air or under shelter, to dry or cure.

There are vast beds of peat in New England and New York, and it behooves our farmers to avail themselves of it, and thus, while turning "unprofitable" land to account, preserve their forests, which are now rapidly used up for fuel, till better uses can be found for them.

IMPROVED MACHINERY FOR WORKING GOLD AND SILVER ORES.

Messrs. Whelpley and Storer, of the Boston Milling and Manufacturing Company, have introduced machinery for the pulverization of gold and silver ores, in which mechanical principles are applied that have never before been employed for such a purpose.

The ores are broken, in the first instance, by the rapid movement of a circular iron table, a mass of metal 3½ feet in diameter, weighing 800 pounds, making 1,025 turns per minute. The table itself forms the bottom of a cast-iron tub, 18 inches in depth, of which the sides are grated, or perforated with small openings. The entire structure, except the upright shafts upon which the table revolves, is of cast-iron, the wearing parts being of what is called Franklinite iron, which is so hard that it cuts glass. The upper surface of the whirling-table, or bottom of the tub, is furnished near its circumference with several blocks, called cutting or splintering blocks, also of Franklinite.

The material to be broken, being fed into the tub through the hopper, drops until its lowest point receives a shivering blow from the upper edge of the rapidly-revolving blocks, by which it is constantly thrown upward and outward against the sides of the cylinder, being reflected back upon the blades until it is sufficiently comminuted to pass through the perforations into the surrounding box or chamber.

The weight of the table, with its case, shaft, frame, cutters, etc., complete, and packed ready for transportation, is about 3,600 pounds.

An average of twelve-horse power is allowed, in practice, for the full work of a whirling-table.

The whirling-table is more rapid in its action than any other machinery for cutting or breaking. It is capable of reducing more than 200 tons of ordinary quartz, in pieces from three or four inches in diameter, to coarse gravel size, in twenty-four hours. It has reduced eighteen tons of quartz into gravel, in one hour, through three-quarter-inch holes.

The broken fragments are swept through the holes or grating of the tub the instant they are produced, by the immediate action of the advancing faces of the cutting blades. Thus it happens that no part of the work of reduction is performed by the sides of the tub, but solely by the blades. The table is made strong enough to bear 1,500 revolutions per minute, without rupture; but any speed above 1,025 turns per minute is wasteful of steam power, and does not much increase the yield.

In general, the higher the velocity of the whirling-table, the less it wears, according to the amount of work done.

The whirling-table is intended to reduce ores, from a diameter from three to six inches, to the condition of mixed sand and small gravel, chiefly the latter, with a small per centage of dust.

The pulverizer is constructed solely for the pulverization or reduction to dust of sand, gravel, or the small work of stamping machines, and cannot be used itself as a crusher or breaker. It consists of four parts or elements, all of which are necessary to its use. The first is an automatic feeding-mill, which furnishes a regular and constant supply of the material to be pulverized.

The second element is an iron drum or cylinder, containing an air-wheel, which converts the sand or gravel into dust by the action of rotary currents of air, created by the wheel. No air enters or escapes from this cylinder, unless by the aid of other machinery. The material can be retained in the cylinder until it is completely reduced.

The third element is a fan-blower, —placed near, or at a considerable distance from, the pulverizing cylinder, —by which the dust is drawn from the latter as fast as it is generated. The gravel, sand, auriferous earth, or other material, is pulverized in the first cylinder by the action of currents of air generated by the air-wheel; the dust is then drawn out, in company with air, by the exhaustive force of the fan-blower. The fourth element is a chamber, or series of chambers, to receive and collect the dust generated by the pulverizer. The dust-chambers are variously constructed to suit the nature of the material which is to be reduced, and are adapted either for dry or wet grinding, as may be required. A single pulverizer, applied to the reduction of gold ores, accomplishes with a smaller consumption of steam or water power, the work of forty stamps, and the quality of the work produced is beyond all comparison finer. In a pulverizer theoretically perfect, the principle of its working is the movement of one particle on another, or mutual attrition, promoted by vortices of air.

Three pulverizers will give the work, in quantity, of ninety stamps; and the quality of this work will be so much superior that the miner may safely estimate his profits at twenty dollars per ton, instead of ten dollars, from quartz assaying thirty dollars.

In ordinary practice, but one element of an ore — that of most prominent value — is sought for; the other elements being rejected in slags or escaping in fumes from the furnaces. Reference may be had to the loss of iron and sulphur from copper ores; the loss of copper, iron, and sulphur in working nickel ores and

most of the gold ores of Colorado, California, etc.; and the loss of silver in working many of the copper and lead ores. Besides these are many ores that cannot be worked by any of the present methods; or, at least, only where labor and fuel cost but little. Of these are the low-grade copper ores, with which our country abounds; the mixed ores of galena and blende; of nickel, copper, and cobalt; and of galena and silver.

To work an ore properly, every useful element should, if possible, be converted into a saleable commodity; and the expense of working the ore should be paid by the sale of those parts that are now rejected as refuse.

The first step in our system is to reduce the ore to an impalpable powder.

For this purpose we have designed the breaker or whirling-table, for splintering the ores by percussion, and the pulverizer for reducing them to dust.

It will not be questioned that an ore in the state of powder is in the best condition to be acted upon by chemical reagents. Having, then, accomplished this first step, the next is the use of the water furnace, which consists of a hollow tower or upright flue of masonry, in the form of a truncated cone, and a horizontal flue starting from its base. The bottom of the tower and flue is formed by a water-trough, in which is a horizontal shaft, furnished with paddles, which is made to revolve to keep the burned ore in motion, that it may be thoroughly lixiviated. Around the head of the tower are four fire-boxes, together forming a cross with a voided circular centre.

Their tops are arched so as to form a flue inclining downward, to approach the tower-head. Resting upon the tops of these arches is a dome, which has a central opening, through which the ores and reagents are fed into the furnace. At the extreme end of the horizontal flue is a draft and spray-wheel revolving in a chamber. A wooden flue or conductor leads from this to a second wheel of the same character. We fill the trough with water, kindle the fires, and set the draft and spray-wheels in motion. The action of the wheels draws the converging flames from the fire-boxes down the tower. These flames extend down but a short distance, depending upon the kind of fuel used, and but slowly heat the tower; resort is therefore had to the use of pulverized fuel, in order to obtain the desired heat. There are two fan-blowers; one to supply air, the other to force powders of any kind into the head of the furnace.

These blowers are now put in motion, the second one forcing pulverized tan bark, or coal of any kind, into the flames proceeding from the fire-boxes.

The minute particles of pulverized fuel, each surrounded by its atmosphere of oxygen, ignite with intense combustion. Both equivalents of heat are applied at the point of work. By this method, in the furnace we have now in operation, fifty pounds of charcoal will create an intensely hot flame twenty feet long and three feet in diameter, and lasting an hour.

The walls of the tower now radiate an intense heat inwardly,

which is, of course, greatest at the point of the intersection of the rays, which is the centre of the tower.

If the ore to be worked be a sulphide of copper or iron, for example, containing sulphur sufficient for its own complete combustion, the supply of pulverized fuel is now cut off, and the pulverized ore fed into the furnace by the second fan-blower. Falling into the focus of radiation, with a sufficient supply of oxygen from the fan-blower, the oxidation of each element of the ore is almost instantaneous.

Most of the ore falls at a bright red or white heat into the water of the tank.

Many ores furnish their own fuel in the sulphur they contain.

When ores containing but little sulphur are to be burned, the supply of pulverized fuel must be constant.

In working ores containing copper, this metal is found in solution with some iron, as a soluble salt, the nature of which will be according to the character of the bath.

We have introduced important economies over the ordinary methods of separating the two metals, and obtaining the precipitates. The separation and refining of the metal is effected in the solution.

In working the mixed ore of sulphides of lead and zinc, the lead is found as a sulphate in the bottom of the water-tank, and the zinc as sulphate in solution.

Not the least interesting features in our system are the application of the pulverized fuel and its economies. There is not only a large economy of heating force, but other consequences which are found to be valuable.

It is a fair estimate, that, in working copper ores, this method requires not more than one-eighth as much fuel as is required by the so-called English or German methods.

The effect of the spray-wheel, which should perhaps be called a water-pulverizer, in wetting down or condensing dust and fumes that would otherwise escape, should not be overlooked. The general use of it will convert many losses into profits, — the losses made in the ordinary methods of working copper, zinc, and antimony ores for instance, — and by it many serious nuisances will be abated.

HORSE-POWER.

Horse-power is a unit of force introduced by Watt, to enable him to determine what size of engine to send to his customers, to supersede the number of horses which the new power (steam) was to replace. He ascertained, at a London brewery, that the average force exerted by the strongest horse was sufficient to raise 33,000 pounds one foot high in a minute; thus, an engine of 200 horse-power would be a force equal to that of 200 horses, each lifting 33,000 pounds one foot high per minute. Watt had two methods of estimating and comparing his engines, viz., by the power, and by the duty. By the power is meant the quantity of work which an engine can effect in a given time; by the duty is meant the quantity of work which it can effect by a given expenditure of fuel. Now, it is evident that, without any change in

the size of an engine, but simply by increasing the pressure of the steam, the power of an engine may be greatly increased; that is, the load remaining constant, the speed of the piston may be increased, the number of strokes may be increased, and consequently the work done per minute will be increased also. Hence it is difficult to apply a limit to the power obtainable from the smallest cylinder, provided the boiler be large enough to evaporate the increased quantity of water, and strong enough to resist the increased bursting pressure. In fact, no size of cylinder can be reckoned as having a particular power, since the power depends not on size but on strength. Nevertheless, in modern engineering, the term horse-power refers rather to the size of the cylinder than to the power exerted; and the value of this unit has undergone many changes, so that in a modern engine a horse-power may imply 52, or 60, or 66,000 pounds, one foot high, per minute.

The plan now adopted for ascertaining the performances of different engines, is by an instrument called an indicator. This consists of a small cylinder, fitted with a piston, which is pressed down by a spring. By the height to which this piston rises against the spring the steam pressure within the cylinder is indicated; and the number of pounds pressure on the square inch, multiplied into the number of square inches in the area of the cylinder, and by the number of feet travelled through by the piston per minute, gives the impelling power; deduct, in large engines, about one-tenth for friction, and the remainder is the efficient moving power, which, divided by 33,000, gives the actual horse-power.

ADVANTAGES OF SUPERHEATED STEAM.

Mr. H. W. Bulkley of New York makes the following communication in the "Journal of the Franklin Institute" for October, 1866. "Superheated" steam, or steam which has received an increase of temperature without increase of weight, by the direct application of heat, has enemies who stoutly maintain that no benefit can be derived from the superheating, as the steam has its maximum efficiency as soon as generated.

The fallacy of such statements is evident on reflection, and plainly shows that those advancing and upholding them have neither practical acquaintance with the subject, nor have given it serious thought. It is clear that, as the greater part of the steam generated in boilers is obliged to pass through the water above it, on its way to the steam-pipe, it must unavoidably carry with it much water in the form of spray, mechanically combined, and held in suspension. When boilers "foam," this operation is greatly increased by unnatural causes, the delivery of spray becoming so great as to seriously inconvenience the engine, and endanger its safety, as well as that of the boiler. And, in boilers properly constructed and carefully operated, which may be supposed to work dry steam, much more water than is generally conceived is constantly carried over with the steam; and this defect cannot be entirely remedied, even by the most judicious arrangement of "dry pipes," steam-drums, etc. What, then, becomes of this water

mixed with the steam, and which has been heated at the expense of the fuel? It is evident that it is useless for power, and, as it has no latent heat, it is very unavailable for heating or drying purposes. It cannot act otherwise than as a "clog," causing more friction in the steam by its presence, inconveniencing the operation of the engine, and tending to condense the steam with which it is associated. Now, by superheating this wet, saturated steam, it is converted into an elastic vapor, by the complete and instantaneous vaporization of its surplus moisture, while its temperature is raised sufficient to preserve it from premature condensation in passing to the cylinder, or to the heating or drying coils. The volume and elasticity of the steam is thus increased to a wonderful extent by a very moderate degree of superheating, and its subsequent operation in the cylinder is highly satisfactory. But another advantage in the system should not be overlooked, and that is the expansion of the steam as a gas, by the heat imparted to it after its surplus moisture has been evaporated. Although the greatest gain must ensue from the addition of the first few degrees (say fifty) of heat, when the expansion of the steam from its previous saturated condition is very great, yet the highest authorities agree, that, after it is thoroughly dried, the steam follows the laws of gases, and its volume may be doubled by the addition of 480 degrees of heat. It is a fact proved by most accurate experiments, that the higher the degree of superheating, the greater is the economy; and if steam could be used at a temperature of 1,000 degrees, its efficiency would be very largely increased. Inasmuch as it is not practicable or convenient with engines, as at present constructed, to use steam at such extreme temperatures, we are unable to realize the greatest economy of superheating; but, if ordinary steam of 50 pounds pressure, at a temperature of 301 degrees, be superheated to 400, the addition of this 99 degrees of heat will augment its volume (or pressure) more than 20 per cent., and will not render it at all injurious to the lubrication or packing. Where this superheating is effected by the waste products of combustion, the increase referred to is all clear gain; but when acquired, as is frequently done for convenience, at the expense of the fuel, a simple calculation shows that even then the economy from the expansion as a gas is from 10 to 15 per cent., independent from that realized in the vaporization of its surplus moisture, and which is as much more. Saturated steam cannot part with any of its heat without becoming condensed; and this loss, by premature condensation, is often a very large percentage of the total amount of steam used. In every unit of the steam thus condensed, there are lost 1,000 units of heat, which have been supplied by the fuel, but have not been utilized. Superheated steam, under the same circumstances, might lose all of its surplus heat, but would still exist as steam.

In England, where the practical advantages of superheated steam are more thoroughly understood and generally acknowledged, its employment is common, and is attended with the most satisfactory and economical results. The steamers of the "Penin-

sular and Oriental Steam Navigation Company" have used superheated steam for many years, and its Directors certify that it has saved them many thousand tons of coal. In this country, the steamers of the "Bay Line," running between Baltimore and Fortress Munroe, employed superheated steam with an economy of 30 per cent. in their fuel. The steam, which was superheated by means of an arrangement of tubes in the uptake, was maintained at a temperature of 400 degrees in the cylinder; yet a subsequent inspection of its interior surface, after using this steam for several months, showed it to be as smooth and polished as a mirror. The writer's experience in the practical application of superheated steam with stationary boilers has shown that where the steam was superheated by the fuel about 100 degrees above the temperature due to its pressure (giving a temperature of 400 degrees in the cylinder(, the saving in feed-water, or steam, was nearly one-third, and the economy in fuel was one-quarter, showing that from five to eight per cent. of the fuel was required for superheating the steam generated by the remainder, thereby increasing its efficiency nearly one-third. With this temperature maintained in the cylinder, by a judicious arrangement of the superheating apparatus, the operation of the engine was highly satisfactory, no water being present to necessitate the opening of water-cocks, or bring undue strains upon the cylinder-heads or connections. It is hardly necessary to add that no appreciable action could be observed upon the lubricants, packing, or working surfaces of the engine.

The full economy due to the use of steam expansively cannot be realized when it is employed in the saturated condition, owing to its partial condensation during expansion. As heat and power are correlative terms, steam cannot perform work without the diminution of a portion of its heat, besides that lost by radiation. This heat, corresponding to the work done, may be taken from superheated steam without destroying its efficiency; for it will still remain in the cylinder, pure and dry, to the end of the stroke. It can be confidently asserted, that no steam engine is entitled to that name, if it employs a mixture of water and vapor instead of the genuine article. The objections sometimes advanced on the score of "want of durability" in superheating apparatuses may be entirely removed by the exercise of a proper care in their construction and application, and by the allowance of a liberal amount of heating surface; so that it is not necessary to subject the superheaters to an undue degree of heat, which would naturally tend to their destruction. These particulars faithfully complied with, it will be found that no tangible objections can be opposed to the employment of moderately superheated steam; and, when such economical results obtain from its use, it seems unaccountable that it is not more generally appreciated, and that the manufacturing public still adhere to the old saturated article, wasting by it both their time and money. The practical advantages attending the use of superheated steam, either when used as power, or for heating and drying purposes, are immense; and it is to be hoped that, with the increased diffusion of knowledge,

the old prejudices against it may be removed, while its true merits are openly and universally acknowledged.

HOLLOW STAY-BARS FOR STEAM-BOILERS.

The safety often of many persons depends on the efficiency of the stay-bars of a steam-boiler; but too often their importance is not sufficiently recognized, or they are weaker or less numerous than they should be, that a little additional profit may be made by the boiler-maker. A still greater source of danger exists when they have been used, but have become so corroded as to be practically worthless; which, from their position, is very likely to be the case, and without its being probable, or perhaps possible, to discover the change they have undergone. A very simple and effective way of making them proclaim their own inefficiency is now in use on the Northern Railway of France. They are made with a small bore from end to end, and thus when one of them gives way, or is seriously corroded, the steam or water escapes through in such a way as infallibly to attract attention. To prevent their being stopped up by dust, etc., their extremities, where not otherwise protected, are loosely closed with wood, etc., which is easily blown out by the escaping steam or water. From the smallness and position of the bore, which is exactly in the centre, the rod is scarcely at all weakened by it, but the necessary strength may be secured by a very slight augmentation of its diameter.—*Intellectual Observer, April,* 1866.

MONT CENIS RAILROAD.—CENTRE-RAIL SYSTEM.

On account of the long time which must yet be consumed before the Mont Cenis Tunnel is finished,—four and a half miles yet remaining to be executed,—it is proposed to place a temporary track over the summit of the mountain. An experimental line of one and a fourth miles has been constructed on the most difficult portion of the route. By the report of Capt. Tyler, of the Royal Engineers, this distance is ascended in eight and a half minutes with a load of sixteen tons, though the average grade is as steep as one in thirteen, and at a maximum of one in twelve. The plan adopted to obtain adhesion is an arrangement of horizontal drivers biting on a central rail. This plan, though regarded as new in Europe, was long ago patented and used in America.—*Journal of the Franklin Institute, Nov.,* 1865.

A paper on the same subject was communicated to the British Association, in 1866, by Mr. J. B. Fell. After alluding to the various difficulties presented to the advance of railways by mountain ranges, and the efforts made to overcome them, it was stated that the use of the centre-rail was first thought of by Messrs. Vignolles and Ericsson, in 1830, and proposed to be applied to the inclines on the Manchester and Liverpool Railway; but it was not put into operation. In ignorance of what was then done, Baron Leguir, in France, the writer, and others, also applied their minds to a solution of the problem of constructing railways over steep gradients. It was not till Mr. Brassey and the writer built a centre-rail engine, and laid down a length of line on that plan on

the Cromford and High Peak Railway for experimental purposes, in 1863, that the system was put into practical operation, the experiments being entered into in order to satisfy the Italian Government as to the feasibility of laying down a line on a similar principle over one of the Alpine passes. The mean gradient of the first twenty-four miles of line, from St. Michael to Lausleburg, is one in sixty, with a maximum gradient of one in twelve; the other twenty-four miles, the mean is one in seventeen; and over the whole length there are at intervals curves of two chains radius. The line rises to an elevation of seven thousand feet, and is exposed in places to avalanches and heavy snow-drifts; but it will be suitably protected. The system of locomotion adopted was that of a third or traction rail, on which adhesion could be obtained by horizontal wheels, worked by the engine in conjunction with or independently of the ordinary driving-wheels, which admitted of the weight of the engine being reduced to a minimum, while the pressure upon the middle rail could be carried to any required amount, and gradients of one in twelve worked with as much certainty and safety as those of one in a hundred. The centre-rail also furnishes the means of applying most powerful brakes for controlling the descent of the trains, and greatly diminishes the frictional resistance in passing round sharp curves. Besides this, the centre-rail rendered it almost impossible for the train to leave the rails. The first experiments were tried in the Cromford and High Peak Railway from September, 1863, to February, 1864. The weight of the engine and load was from sixteen to seventeen tons. It never failed to take loads of from sixteen to twenty-four tons up gradients of one in twelve, or in working round curves of two and a half chains radius on that incline, the brakes having perfect control over the train on the ascent. Certain improvements suggested themselves, — the boiler-power was insufficient, the inner machinery too crowded and inaccessible, and the connecting-rods, working at too great an angle, by an irregular, impulsive movement, diminished the adhesion of the horizontal wheels. The improvements were made and further experiments conducted with special reference to the requirements of the Italian Government, which included three trains a day each way, the mail train to perform the journey at an average rate of twelve miles an hour, including stoppages, the speed up the steepest incline being seven and a half miles an hour, while the gross weight of the train was to be sixteen tons. The mixed and goods trains were to carry forty and forty-eight tons each, with two engines. The traffic on these trains represented a return of £100,000 annually. The writer described the official trials in Italy in the presence of the representatives of the English, Italian, Russian, and Austrian Governments. The result of the trials exceeded the estimate both as to speed and weight of the trains, and Captain Tyler, who represented the Board of Trade, reported "that this scheme for crossing the Mont Cenis is, in my opinion, practicable, both mechanically and commercially, and that the passage of the mountain may thus be effected, not only with greater speed, certainty, and convenience, but also with greater safety, under

the present arrangements. . . . There is no difficulty in so applying and securing that middle-rail, and making it virtually one continuous bar, as to preclude the possibility of accident from its weakness or from the failure of its fastenings; and the only question to my mind is whether it would not be desirable still further to extend its application to gradients less steep than one in twenty-four, with a view to greater security, especially on curved portions of the line." Similar favorable reports were quoted from the French Imperial Commissioner, while it was stated that those of the Italian, Russian, and Austrian Commissioners were equally favorable and conclusive. In November and December last, the French and Italian Governments granted concessions, authorizing the railway on the Imperial postal road over the Mont Cenis with a width of about thirteen English feet; and a company has since been formed to carry out the undertaking. The works were commenced in March, and the line is expected to open in May next.

Attention was directed at some length to the conditions essential to the success of the system, the first of which was the employment of different types of engines, according to the heaviness of the gradients; of each of which full descriptions were given, with the aid of colored diagrams. The carriages, as well as the engines, are each furnished with four horizontal wheels, which have flanges underlapping the centre-rail. These act both as guide and safety wheels, preventing the carriages from leaving the rails, and, by guiding them round the curves, greatly diminish the frictional resistance and the tractive power required, thereby rendering it easy to reduce the weight of the engine to that which was necessary for producing and carrying the power required for the traction of the train. The economy of weight has been effected by a simpler arrangement of the machinery, and by using an improved quality of material. For the making of mountain lines, which are exposed at certain seasons to an unfavorable climate, from the effects of snow, frost, and fogs, it was desirable to devise some means of cleaning the surface of the rails, and for improving the state of adhesion as the trains advanced, so as to dispense with the use of sand. This might be done at speeds from five to ten miles an hour; ice and snow might be cleared off by cutters attached to the engine; and, in seasons of mist, new machinery could be probably contrived for removing that almost imperceptible film of mist which diminishes the adhesion to nearly the same extent as ice. The adhesion was best in the winter, when the snow remained for months in a state of dry powder; but the places where it accumulated were protected by covered ways, and the rails were always in good condition.

He said that the centre-railway system was never intended to be worked on any except the steepest inclines, where no other engines could work. It would be only necessary to have a covered way for fourteen kilometres, which would cost £40,000. One kilometre in the avalanche district, which was well known, would have to be protected by stone; but the remainder would be protected by wood, which was amply strong enough to resist the weight of from twenty to thirty feet of accumulated snow. — *Reader*, 1866.

PNEUMATIC RAILWAY.

The Pneumatic Dispatch Company have successfully applied the principle of atmospheric pressure to the conveyance of letters and merchandise, and thus afforded an opportunity of showing that human beings may continue without inconvenience in a closed tube. This removal of an apparently insuperable objection to atmospheric propulsion is very important, since, with a pneumatic railway, the danger of accident is reduced almost to nothing. Collisions are impossible; and, as the train cannot get off the line, the greatest velocity is unattended with danger. The view of external objects is excluded; but this privation is little greater than that experienced on ordinary railways, where there are many cuttings, tunnels, and interposed objects. With an atmospheric railway, the expense of construction and maintenance are greatly diminished; steep gradients and sharp curves cease to be objectionable, since an ascent of one in fifteen, or a curve of eight chains radius, causes no inconvenience, and great facilities are afforded by it for passing under rivers.

The tubes of the Pneumatic Dispatch Company have been in operation for more than three years, in conveying parcels; and the applicability of the system to carrying passengers has been amply demonstrated. The line of the Waterloo and Whitehall Railway is to cross the river just above Hungerford Bridge. The tube is made in four sections of two hundred and thirty feet length each. The ends of these will be connected by being introduced into junction chambers formed in the brick piers on which they rest, the joint being made water-tight. These piers do not rise as high as the present river bottom, and a channel will be dredged across the river to receive the tubes, though the principal weight will be supported on the piers. One of the tubes is now completed at the ship-building yard of Messrs. Samuda, at Poplar, five miles below its intended situation. It is twelve feet nine inches in diameter inside, and is of three-quarter-inch boiler-plate, surrounded by four rings of brick-work, which is firmly held by cement and flanged rings riveted to the plates. Its weight, as it lies, is nearly one thousand tons. To convey it to its destination, the ends are to be closed by bulkheads, and then, having a buoyancy when in the water of about three hundred tons, it will be floated up the river and brought into position over its piers. An inner ring of brick-work will then be built inside it, and just enough water admitted to sink it upon its foundation. The joints between the tubes and piers will then be made water-tight, and the bulkheads removed from the ends of the tubes. The four tubes will thus form a great sub-aqueous bridge of four spans of two hundred and twenty-one feet each, the tubes resting in a channel dredged across the bottom of the river, but being chiefly supported upon massive piers which do not rise even to the river bottom. The coffer-dam at the Whitehall end of the line is no less than fifty-three feet deep.

When the underground tunnel was finished from Holborn to Easton Station, a distance of two miles, a train of goods with an attendant was sent through the whole distance in five minutes.

It appears from recent experiments conducted by the London Pneumatic Company, that one hundred and twenty tons of goods can be sent through their eighteen miles of tubes every hour, at a cost less than one penny a ton per mile. — *Intellectual Observer and Scientific American.*

AERIAL LOCOMOTION.

A pamphlet has lately been published on this subject by Mr. Boulton, from which may be gathered many interesting facts. After giving it as his opinion that balloons will never permit us, safely and at pleasure, to navigate the air, on account of the vast surface they present to the action of the wind, he proceeds to show that if the problem of aerial navigation is to be solved, the encumbrance of balloons must be altogether dispensed with, and an engine must be devised capable of lifting its own weight and that of an aeronaut into the air, and of continuing to exert the power requisite for this purpose for a considerable time. There is no difficulty in devising mechanical instruments for aerial propulsion and guidance. Earlier projectors principally aimed at imitating the wings of birds; but since the use of the screw for the propulsion of steamers, the employment of a similar propeller for aerial locomotion naturally suggests itself. The action of such a contrivance is illustrated by a small toy called the Stropheore,* sold for the amusement of children; when a string pulled by the hand, giving a rapid rotation to a miniature propeller, causes it to rise in the air. It is also illustrated by fire-works called the Chinese turbine, which rise similarly in the air when caused rapidly to revolve by the combustion of the explosive mixture. There is no reason to apprehend any particular difficulty in the mechanical adaptation of this principle to the purpose under consideration. The real difficulty lies in obtaining a suitable motive power, *i. e.*, one capable of furnishing a sufficiency of power without weight. In the case of the steam-engine, which first occurs to the mind as the possible agent of the propulsion, the chief objection is the weight of the boiler, coals, and water; that of the cylinder, piston, and moving parts being comparatively trifling. The caloric-engine, although dispensing with the weight of water, does not on the whole offer prospect of advantage. Another source of motive power is offered by the combustion of gas, *i. e.*, by exploding a mixture of inflammable gas with atmospheric air. In a gas-engine constructed on this principle, the weight of the boiler, coals, and water necessary to the steam-engine is altogether dispensed with; the place of these being supplied by a receptacle of gas, a source not of weight but lightness. There is one difficulty, however, viz., that if the receptacle of gas be large, without which long journeys would be impossible, difficulty of propulsion and guidance, as in the case of a balloon,

* In the Stropheore we have a few light wings placed obliquely around a central stem: by the action of the hands with a string, as in a humming-top, rotation is imparted to those wings, and immediately the machine rises, and pierces its way through the air. So long as the motion continues, this ascent is continued, because the air, subject to great compression, yields to impulsion before it has time to veer.

would be created. This evil would be remedied, though not without sacrifice of lightness, if a stock of petroleum were carried instead of a receptacle of gas, and the vapor of petroleum used instead of gas for explosion, with a due admixture of atmospheric air. Another source of motive power is afforded by solid explosive substances, *i. e.*, by compounds which on combustion generate a large volume of gaseous products. Such are gunpowder, gun-cotton, the mixture used for rockets, etc. In case of an engine worked by such power, the weight of boiler, fuel, and water necessary to the steam-engine is replaced by that of the supply of explosive material, whereby for short journeys a great reduction in weight is effected. There are some further considerations which seem to show that these powers are capable of achieving, to some extent, the desired result, which the steam-engine, probably with justice, is pronounced incapable of effecting. If a very diminutive steam-engine could be made capable of raising itself into the air, a powerful steam-engine could be made to do so likewise; for the ratio of weight to power is greater when the steam-engine is small than when it is large; and this holds good in the case of most machines or engines. Now, rockets are actually made capable of lifting themselves into the air, and if small rockets can do this, surely, in accordance with the above principle, large rockets can do so too, and in proportion to the size of the rocket, its power of lifting a load will increase; and if this be so, it must be possible to construct a rocket, or a combination of rockets, capable of lifting from the ground and transporting to some distance the weight of a man. The weight actually lifted by the larger Congreve rockets is not inconsiderable; but it is proper to consider that this would be greater were the power of the gas brought differently into play. For the rising gas acts much more advantageously when the rocket is moving at a high velocity than when it is stationary, — a large proportion of its power being wasted in the latter case. Could the power act as advantageously when the rocket is stationary as when it is moving at full speed, it would be capable of lifting from the ground a greater weight than it actually does; and a greater supply of material being lifted, an increased range of flight could be obtained. For this reason, a rocket, however great its power, would be wholly unsuited to the purpose of aerial navigation; it being impossible to retard its speed without diminishing the power exerted by it. But no such objection exists if we conceive the gas to produce motion, not directly, but by means of a propeller. For the propeller may revolve at full velocity, and thus the maximum of available power be brought into play, while the engine itself is moving through the air slowly or not at all. The same reasoning holds in reference to the Chinese turbines — *i. e.*, that the ratio of weight to power would be greater when they are small than when they are large. And in this case, if a small turbine can lift itself into the air, *a fortiori*, a large one can do so. Such considerations seem to show that, though the steam-engine may be wholly incapable of accomplishing the feat in question, yet that other powers now known to us are capable of effecting

it to some extent. Suppose, however, that this be so, the question still remains: "What range of flight could be attained by means of any power now known to us?" This would of course be limited by the quantity of material (whether petroleum, gun-cotton, or any other substance) which it would be possible to lift into the air; and experiment alone would determine this point. It does not seem very bold to anticipate that a range of flight equal to that of a cannon-ball might be found attainable without much difficulty; and if once such a beginning be made, improvements might be expected to follow, enabling greater distances to be performed. Another question is that of cost; this would, of course, mainly depend on the nature of the material available for the purposes. Could the desired object be achieved by the use of petroleum, the cost would be comparatively moderate; while if it were necessary to employ gun-cotton, the mixture used for rockets, or similar explosive compounds, the cost would be very great. It is obvious that in any case such a means of locomotion would be far more costly than those now practised on land and water, and wholly unfitted to compete with them for ordinary purposes. At the same time, it is manifest that there are numerous occasions, especially in warfare, where the power of moving in any desired direction through the air, even for very moderate distances, would be of great service; and cost for the accomplishment of such an object would not be grudged.

ON THE USE OF STEEL FOR RAILWAY PURPOSES.

The application of steel to many of the purposes for which iron had been and is now generally used, had been limited by the difficulty in producing steel in sufficiently large masses, at a comparatively low cost, and free from flaws, with a perfect homogeneousness of material, — this seemed to present an almost insuperable difficulty to its general employment. Cast-steel made by cementation, while possessing superior hardness, lacked tenacity; if tough, it was soft; if hard, it was brittle. In 1851, however, Krupp, of Essen, Prussia, showed, in the London Exhibition, an ingot of cast-steel weighing 4,500 lbs., the heaviest then known. In 1862, he exhibited another one weighing twenty tons, in the form of a solid cylinder, nine feet high and three feet eight inches in diameter. It had been broken across to show its fracture; under a good microscope it would not exhibit a single flaw. Since then he has repeatedly produced masses of forty tons weight.

There can be no reason, at this late day, and in view of the experiments made in England and on the continent, for doubting the superior durability, and the ultimate superior cheapness, of steel rails and tires over those of iron. On our railroads it is theoretically correct to say that the weight of a load rests on a point; but it is not practically correct. There is compression; much of it in the road itself, or the rail, but some of it in the wheel or tire. Yet, notwithstanding that it can be demonstrated

that this compression makes what would otherwise be a level road one continually up-hill, there are persons who advocate a yielding foundation, as there are those who insist on a springing or yielding tire. The mere fact that our ordinary locomotive tires must be occasionally re-turned is a sufficient refutation of their position.

A perfectly rigid bed or road-way, and as rigid wheels, is the rule that is found by experience to be the best. Soon as a wheel or tire gets "out of round," it becomes, in operation, a hammer, destroying the rail. Mr. Bessemer, at a recent meeting of the British Association at Nottingham, gave an exceedingly elaborate and interesting account of his own system of manufacturing steel, and showed the vast importance that branch of industry had assumed since his patent had come into working operation. By the old system, forty pounds of steel was the largest mass of metal operated upon; but by his process as much as twenty-five tons could be converted into steel in one heating. It had superseded iron wherever large castings were required, such as ordnance of large size, locomotive and marine engine-cranks, rails, etc. He mentioned, as showing the superior durability of steel rails over those of iron, that at the station at Camden Town, at a part of the line over which all the traffic passed, a steel rail was placed on one side of the line, and an iron rail on the other, and that seventeen faces of the iron were worn away, while the first face of the steel rail was still in working order. Steel rails put down four years ago were still in working order. The first cost of steel rails was, of course, much greater than that of iron, but compensation was found for this in the greater durability.

The superintendent of one of our most successful railroads informs us that iron rails on that road average about seven or eight years of life. Steel rails have been recently introduced, but the test is not considered sufficient to afford proper data for an opinion. Steel tires have been used on the road several years, some of them having already run 70,000 miles, and, while costing double the price of iron, their durability has proved that they are superior to iron ones. No such performance, we are certain, can be recorded for iron tires. The "best iron tires" — according to Thomas Prosser, C. E., who has lately issued a pamphlet on this subject, which should be a satisfactory exhibit to our railroad men — "average only 60,000 miles, during which time four of them will grind up one ton of rails."

It appears to be evident that our railroad companies will eventually save by replacing their iron rails, iron tires, iron wheels, and iron locomotive axles, with those of steel, the rails to be laid on an unyielding and permanent foundation. Certainly, this subject of the comparative value of iron and steel for these purposes is worthy more general attention than has been given it in this country, especially in the construction and "plant" of new lines of railways.

The surprising results that have appeared where steel rails have been laid alongside of iron rails, in places subject to very heavy traffic, have already caused their adoption on nearly all lines for

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use near stations, and at all places where the way is liable to great deterioration. The great Northern Railway has adopted them for use on all their inclines, while the London and North-western Company have erected works of their own capable of supplying three hundred and fifty tons of steel per week, three hundred of which is worked up into rails. The question is merely one of first-cost and interest, and it is now pretty generally conceded that steel rails at £15 per ton, lasting forty years or longer, are cheaper than iron at £7 10s., lasting eight years, especially when it is considered that, on account of its superior strength and stiffness, a steel rail weighing seventy pounds to the yard is more than equal to an iron rail weighing eighty pounds.

At first it was urged that steel rails, when worn out, would be useless from the impossibility of piling and re-rolling them, while old iron rails could easily be re-worked in any desired manner. All fears on this ground have, however, proved quite unnecessary, as numberless uses have been found for which the old steel rails, as well as the crop ends formed in their manufacture, are desired, so that these bring readily from £7 to £8 per ton. Among these uses may be mentioned rolling into plates, to be used in making kettles, by stamping, instead of charcoal plate; plates for nail-cutting, telegraph wire manufacture, and hundreds of other purposes for which the metal is extremely valuable. Or it may be re-melted in the converter or otherwise, and be again produced as rails. As stated in my last letter, the production of steel rails in England already amounts to one thousand tons per week.

The form of rail in vogue on the Continent is the single headed, but, like the English, five inches deep. Here, also, steel is taking the place of iron on many lines, with a corresponding decrease in the expenses for renewals.

The "London Railway News" says: "Mr. Williams furnishes some details which will serve to show the enormous wear and tear to which the rails of our leading lines are subjected. On the section between Hatfield and London, on the Great Northern line, 57,536 trains, carrying 17,760,926 tons, destroyed in three years the rails laid down in 1857. Some heavier rails, laid in 1860, were worn down in three years by 65,529 trains, and 13,484,661 tons. In the case, however, of a section of railway between Bury and Accrington, 62,399 trains, and a gross tonnage of 12,451,784, passed over rails which lasted seven and a half years, or two and a half times as long as those of the Great Northern, with about an equal amount of traffic. Again, at Bolton, it required 203,122 trains, and 38,-803,128 tons, to wear out the same description of rails in seven and a quarter years. The cause of this rapid wearing out of the rails of the Great Northern as compared with those of the other lines, is due, apparently, to the greater speed of the trains. In the case of iron rails, as in the delicately-constructed mechanism of animal life, it is 'the pace that kills.'

"Two steel rails of twenty-one feet in length were laid on the 2d of May, 1862, at the Chalk Farm Bridge, side by side with two ordinary rails. After having out-lasted sixteen faces of the ordinary rails, the steel ones were taken up and examined, and it was

found that at the expiration of three years and three months, the surface was evenly worn to the extent of only a little more than a quarter of an inch, and to all appearance they were capable of enduring a great deal more work. These two rails had, during the period of a little more than three years, been exposed to the traffic of 9,550,000 engines, trucks, and carriages, and 95,577,240 tons. It is an amount of traffic equal to nearly ten times that which destroyed the Great Northern rails above referred to in three years. The result of this trial was to induce the London and Northwestern to enter very extensively into the employment of steel rails; and we learn from Mr. Webb that in a short time arrangements will be made at Crewe for the production of three hundred and fifty tons of steel per week, of which three hundred will be used for rails; and that at the present time there are about fifty miles of steel rails in use on the line, and three thousand tons of steel-headed rails."

An examination of the steel rails laid down two years and a half since in the Woodhead Tunnel of the Manchester, Sheffield, and Lincolnshire Railway, resulted in a striking illustration of the relative endurance of steel and iron rails. This tunnel is about three miles long, with a station at each end, where trains generally stop, and where the wear of the rails is extraordinary, from the starting of heavy trains with the aid of sand on iron constantly wet with drippings from the roof. The life of an iron rail at these stations was but about five months on one head, and three or four months on the other, after turning. The new rails are seventy-five pounds Bessemer steel, double-headed, two and a half inch face, five-eighths inch stem, and five inches deep. Rails were taken out at the places of greatest wear, at each end of the tunnel, and on being carefully measured and compared with the original templates from which they were made, were found to have lost as nearly as possible one-eighth of an inch in the thirty months' use, under at least 8,000,000 tons of traffic, as computed from the books of the station. The rails were in admirable condition, and good for five times as much further wear, both heads together; making, in insurance phrase, an "expectation of life" equal to fifteen years, or twenty times as long as that of iron. — *Scientific American*, 1866.

CHILLED RAILWAY WHEELS.

The practice with Major Palliser's shot against armor has shown what are the qualities of chilled cast-iron; the chill, in this case, extending quite through the casting. It has been demonstrated that it is equal in hardness to hardened steel, and that it requires even greater force to break or deform it. It may be that the startling results obtained at Shoeburyness will serve, in some measure, to account for the universal use of chilled railway wheels in America, and for the leading wheels of engines, and often for the driving-wheels themselves as well. It has always been the belief in this country that those wheels were used because they were cheap, and because the Americans could afford nothing better. These wheels, before the war, cost about one and a half

pence per pound, or rather less than £14 per ton; and one favorite pattern of two feet six inch wheel, weighing nearly four hundred weight, was sold, ready for boring, for £2 10s. each. But so far from their cheapness having alone maintained them in use, they were long ago adopted on the Grand Trunk Railway of Canada, because they were found, upon the whole, better than wrought iron. We have before us a letter, written, in 1859, by the late Mr. A. M. Ross, engineer to the Victoria Bridge, Montreal, upon this subject, and which contains this statement, a statement which we know to have been confirmed by the subsequent experience of the engineers of the Grand Trunk Railway. In the International Exhibition of 1862 were a pair of chilled wheels, two feet nine inches in diameter, which had run upward of 150,000 miles under a heavy post-office van on the Grand Trunk Railway, and, although worn, they were still in good condition. We need not dwell upon the severity of a Canadian winter, nor explain how for months together the road bed — and there is seldom much ballast — is frozen as hard as rock.

This, if anything, would be expected to try chilled wheels; yet they are regularly employed for the leading-wheels of passenger engines; and breakages, although not absolutely unknown, are at least as infrequent as those of the best makes of English railway carriage-tires.

It requires good iron for chilled wheels. That used in America for this branch of manufacture is mostly cold-blast charcoal iron; and it has to be selected and mixed with care to obtain the proper qualities of strength and hardness of chill. The chill should be from three-eighths to five-eighths of an inch deep, and should cover the whole tread and the wearing face of the flange. Chilled wheels require especial provision for cooling after being cast, so as to avoid internal strain from contraction. The wheels do not all come out of exactly the same diameter; but there is no difficulty in mating them in pairs of equal diameter, the greatest variation in the diameters of a thousand two-feet-nine-inch wheels hardly exceeding one-eighth of an inch. The machinery employed for boring is such that the hole is necessarily in the centre, so that no eccentricity is possible. The wheels wear evenly and very slowly, until their diameter has been reduced by nearly half an inch. American iron, of choice quality for chilled wheels, is now being taken to St. Petersburg for casting there the wheels of all the carriage and wagon stock of the St. Petersburg and Moscow Railway. Heretofore the wheels for that line have been imported largely from the States. Our own size of wheel has never been adopted there; and as the weight of disk-wheels increases in a higher ratio than that of the increase of diameter simply, we presume that a three-feet-six-inch wheel, instead of weighing but five hundred weight, as in English practice, would reach six hundred weight. We learn that iron of the proper quality for chilled wheels is likely to be introduced into this country, and that they will probably receive a fair trial.

We believe that five American chilled railway wheels have arrived in London, and that they will be broken experimentally,

and that further wheels of this kind will be sent over for trial under English rolling stock. We have samples of the iron from which these wheels are cast, and it is of magnificent quality. The fracture is a rich dark gray, medium-grained, and shows great toughness, the particles appearing to have been irregularly torn, rather than broken short off. The specific gravity ranges from 7.25 to 7.3185, and the tensile strength from 32,000 to 35,-102 lbs., or, say, fourteen and one-half to sixteen tons per square inch. The iron is that known as the Salisbury cold-blast charcoal iron, and is worth about £10 per ton in New York. — *Engineering*, 1866.

STEEL LOCOMOTIVE WHEELS.

Railway companies in England have for some time largely employed steel as a substitute for ordinary iron, for the working parts of locomotives, with most satisfactory results. On heavy freight-lines it has been found that with the ordinary iron tires, or the engine-wheels, the distance run was not more than 90,000 miles, — in many cases not more than 60,000 miles, — and the wheels require to be taken from under the engine for every 20,-000 or 30,000 miles run, for repairs and "turning up." In the case of steel tires, however, the wheels will run 100,000 miles, before they require "turning up" or repairing. The "Railway News" states that the result of a very careful examination of the effects of wear, lead to the opinion that these wheels will run from 350,000 to 500,000 miles, or equal to some twelve or fifteen years' work of a daily average of about one hundred miles. The difference of cost between the two metals is not great; in the one case it ranges from £40 to £45 per ton, while the steel is about £55; the cost of labor in placing the tires being about the same in each case. It is confidently stated that a similar saving in point of wear may be made by substituting steel for iron in boilers, axles, cranks, eccentrics, and other portions of locomotives. — *Mechanics' Magazine, April*, 1865.

HIGH TEMPERATURES PRODUCED BY GAS.

There is no reason why the very highest temperatures should not be produced by the combustion of gas; and in reality it has been found that by regulating the supply of air and gas, and preventing the caloric evolved from being dissipated, a very great heat may be obtained. For this purpose, it is only necessary to combine a number of flames produced by Bunsen burners, but without permitting them to completely penetrate one another, and causing a draught by means of a sheet-iron tube about two metres high. The heat, by a proper management of the flame, and by the products of combustion being made to act on both sides of the refractory envelope within which the substance to be operated on is placed, becomes extremely powerful. With such an arrangement it was found that two square metres of gas, burned under a pressure of five or six centimetres of water, fused six hundred and seventy grammes of silver in fifteen minutes; and

five hundred grammes of very infusible cast-iron in thirty minutes. — *Intellectual Observer, March*, 1866.

PETROLEUM AS A FUEL.

Mr. C. J. Richardson has so far succeeded in utilizing petroleum as a steam fuel for marine engines, that at a recent trial of his improved petroleum boiler, at Woolwich Dockyard, the most favorable results are said to have accrued. It is reported that the boiler vaporized about three thousand pounds of water, at the rate of thirteen and a half pounds to one pound of fuel, in about three hours, the lowest class of English coal being used. Petroleum is the exact opposite of coal; it is slow burning, permitting little waste, requiring a small fire-box and no ash-pit. An ash, the petroleum coke, forms itself on the surface of the grate, and is of great service to the combustion. After a few tons of the oil are burned, this would become several inches in thickness, and form a porous grate better than any that could be manufactured for the purpose. — *Mechanics' Magazine, Jan.*, 1866.

SIEMENS' REGENERATIVE GAS FURNACES.

Although this furnace has been described in the "Annual of Scientific Discovery" for 1864, the facts elicited are so important and suggestive, that attention may be called to them again. The points of special interest are, 1st, the extremely high temperature which can be obtained, and which, in fact, is limited only by the nature of the materials employed in the construction of the furnace; and 2d, the possibility of employing at will either an oxydizing or a reducing atmosphere. The furnaces have been applied to puddling and re-heating, and, no doubt, will soon be extensively used in metallurgical processes. It is well worth while to determine by direct experiment, on a large scale, whether the rich iron ores of Lake Champlain, Lake Superior, and Missouri, cannot be directly reduced to the metallic state by heating them to a sufficiently high temperature in the chamber of a Siemens' furnace, and then changing the gaseous mixture in the furnace to a reducing condition. This would, in fact, be blooming upon a large scale, and would perhaps avoid the inconvenience and expense of blooming in the small way, which, in spite of the superior quality of the iron produced, has been almost wholly superseded by the cheaper process of puddling. Experiment only can determine whether fluxes can be used with advantage in blooming in this manner, when poorer ores are employed. Ores of copper could doubtless be roasted and reduced in furnaces of this construction, and, with some additions to the original plan, the sulphurous acid formed during the roasting might be directly converted into sulphuric acid in leaden chambers. But it is for the metallurgy of iron that the new furnaces will probably be found most advantageous. As the temperature attainable is extremely high, it may even be found practicable to melt the malleable iron formed by the direct reduction of the ore,

the walls of the fire-chamber being lined with lime, as more refractory than fire-clay. But even if this should not be realized, it is at least probable that the earthy impurities of the ore would be reduced to a peculiarly fluid condition, so that the blooms could be easily treated under the hammer and brought into the form of malleable iron. There is hardly a branch of manufacture in which heat is employed upon the large scale in which furnaces on the regenerative principle would not find an application. Small gas furnaces could be made upon the same principle, for laboratory use and for various processes in the arts, using ordinary city gas as fuel, instead of gas produced by a special furnace. The high temperature obtained in Gore's gas furnaces appears to be due to the heating of the air and gas before they mix in combustion. — *American Journal of Science, May*, 1865.

SMOKE-CONSUMING APPARATUS.

M. Emile Martin, in a work published in London, in 1865, describes his improved steam-generating apparatus. The leading idea is the use of two fire-places, and, therefore, double firing. From the upper part of each fire-place tubular flues rise up to a chamber within the boiler; from this chamber descend one or more flues, at whose lower portion is a perforated grating of fire-clay, on which there is constantly kept a quantity of glowing fuel; below this is a space communicating with a chimney into which the products of combustion are exhausted by means of a fan or other contrivance for producing a draught. In order to try the plan, the Great Eastern Railway Company applied it to an old locomotive, working as a stationary engine at the Stratford station. This old boiler, with M. Martin's apparatus, was able to provide with steam an engine of a hundred horse-power, and with an economy of thirty-three to forty per cent. over the fifty-horse boilers close by. These boilers are still in good condition, and the advantage over them, obtained by the old locomotive-boiler furnished with this apparatus, seems mainly due to the consumption of smoke obtained by the latter. The work also contains a report from two engineers, showing that, by means of this arrangement, ten pounds of water were evaporated by the use of only one pound of fuel, exclusive of the fuel used for getting up steam. A new locomotive on this plan was in process of construction. — *London Mechanics' Magazine, Feb.*, 1865.

AMORY'S SMOKE-CONSUMING FURNACE.

Mr. Jonathan Amory, of Boston, Mass., who has devoted many years to the perfection of a smoke-consuming furnace, has recently issued a pamphlet on the subject, from which the following are extracts: —

"The subject of the economical application of heat for the production of steam may be said, without exaggeration, to be the most important for the consideration of every large manufacturing, agricultural, and mercantile community; and one, too, the

most neglected, as far as practice is concerned. The cost of fuel annually required in the United States for mechanical and manufacturing purposes, and principally for the generation of steam (leaving out of the calculation the immense amount used in domestic economy), has been estimated at $60,000,000. Estimating it at only $50,000,000, any improvement which would save even one-quarter of this sum (or $12,500,000) would add so much to the national wealth, by largely extending many branches of productive industry, and rendering profitable many enterprises now languishing and poorly remunerative. The many different kinds of furnaces and boilers now in use, in this country and in Europe, like the many infallible cures for dangerous diseases, only show that all are imperfect, and that no one is entitled to the full confidence of the public.

"No one can deny that the prevention and consumption of smoke are very desirable, both from a sanitary and an economical point of view. The principles of chemistry, and practical experience, show that the prevention of smoke and the perfect combustion of fuel are synonymous; or, in other words, that smoke is carbon escaping unconsumed from the chimney, and so much lost fuel. Hundreds of thousands of dollars are thus annually thrown away, at a time, too, when strict economy ought to be the rule. It is not exaggerating to say that one-half of the fuel used for generating steam in this country would, with the use of proper furnaces, perform the same service now derived from the whole, as at present used.

"The idea that we cannot have fire without smoke is not true of a well-constructed furnace, after the fire is once well kindled. Many attempts have been made to solve this smoke problem, but all have failed, more or less completely, from inattention to the laws of perfect combustion, the variable products according to the fuel, the want of system in the management of the furnace, and, above all, from the failure to bring the due proportion of air into contact with the combustible gases. Various devices have been employed, both in Europe and this country, to arrest or delay the gases of imperfect combustion in their passage to the chimney, by different kinds of bridges, generally of fire-brick, behind and near the fire; and various imperfect attempts have been made to admit a certain quantity of air behind these bridges, to secure a more perfect combustion, diminishing, however, to a certain extent, the heat by the admission of the cold air. Even with these, in England, there has been secured a saving of thirty-three per cent.

"As a preliminary to perfect combustion, a proper amount of grate-surface, and a boiler of sufficient size, are of the first necessity; as, with too small a fire-surface, and a boiler so small as to require constant forcing, perfect combustion and its resultant economy are out of the question."

After showing the proper proportions of grate-bars to boiler-surface, the heating properties of various kinds of fuel, and the proper amount of air to be supplied for perfect combustion, he goes on to say: —

"In the best double-flued and double-furnaced English boilers, about one square inch of permanent air-opening, behind the bridge, is necessary for every square foot of grate-bar, — air passing as usual through the grate-bars from the ash-pit, and often through holes in the furnace door. In the 'Amory' furnace, a three to six-inch pipe is ample, conveying heated air to the cavity of the curves, the ash-pit door (and the holes in the furnace door, if necessary) being closed, after the fires have been well kindled, — a very much less open air-space than in the best English furnaces. With an insufficient amount of air, if bituminous coal or pine wood be used, the too-compact fire being supplied only through the grate-bars, the gases pass quickly and unconsumed through the flues, with a thick volume of dark smoke by the chimney. Enough air only should be admitted to convert the carbon of the fuel into carbonic acid by its oxygen, the hydrogen being converted into water in the shape of vapor. In this condition of a furnace, the products of combustion become invisible, so that we may justly conclude that smoke is the measure and gauge of imperfect combustion.

"Some furnace-makers admitted air through the furnace-doors by a few large, or many small openings; others, behind the bridge; but, in every case, cold air. In the 'Amory' furnace, at a proper distance from the fire, is placed a combustion, or reverberating chamber of concavo-convex hollow iron curves, concave toward the fire, when a single one is used, and the length of grate-bars is sufficient to admit the loss of so much fire-surface; the curve on the level of and just behind the fire; — concave toward each other when two are used, above and at a greater or less distance from the fire. Between the curved iron plates (best made of boiler-plate one-eighth or one-sixth of an inch thick) is a hollow space, communicating underneath with each, into which air is received, heated by passing through a pipe introduced through the boiler, or otherwise, the air communicating with the fire-chamber by several openings on the concave surfaces. It is also necessary that the anterior curve be lower than the posterior, to insure and facilitate the revolving of the gases in the chamber.

"The principles of this furnace have for several years been applied to locomotive, stationary, house, and steamboat furnaces, with the most satisfactory results, as the testimonials appended will show; and it is confidently recommended to engineers, machinists, and builders, as meriting all that is claimed for it in the saving of fuel and the consumption of smoke.

"This furnace neither draws the air through the fuel by the production of a partial vacuum behind it from high temperature and rarefaction in the chimney, nor forces air through it by compression, or other mechanical contrivance, before the fuel, — the first exceedingly wasteful, and the second inconvenient and unnecessary; but it secures a most perfect combustion and freedom from smoke, by the retention and reverberation of the gaseous products in a circular chamber, in which a due amount of heated air is introduced, converting, in this way, much carbonic oxide (usually escaping by the chimney) into carbonic acid gas, and thus saving a great amount of caloric.

"The three points of the patent are, — 1st, Retention of the unconsumed gases. 2d, Reverberation by a circular chamber of proper relative height in the two curves. 3d, A due supply of heated air in the chamber, and between its plates, doing away with draft in front and from below, after the fire is once kindled, affording safety from fire by closed furnace doors, freedom from water which would put out the fires (by closed ash-pit), and preservation of iron in locomotives by the constant current of the burning gases in the chamber."

It is claimed that, by this furnace, a saving of twenty to forty per cent. in fuel is effected, and that with fuel even of the poorest quality.

ON IRON SHIPS.

Mr. William Fairbairn communicates to the "Quarterly Journal of Science," for April, 1866, a paper on the loss of the "London" steamship, which foundered at sea on a voyage to Australia, from which the following are extracts :

"The introduction of iron for the purposes of ship-building has given greatly increased strength, and afforded facilities for obtaining new forms, which, aided by the power of steam, have insured a rate of speed in vessels never before attained in naval history. It has, moreover, furnished the naval architect with a material of immense value as regards construction; and its careful distribution in the shape of ribs, frames, and the sheathing of vessels, cannot be too highly appreciated. As compared with the best English oak, it exhibits four times its power of resistance; and it has, in addition, the double advantage of being almost perfectly homogeneous and free from the defects of open joints, which, in the case of the planking of wooden vessels, require to be caulked. With all these advantages, iron constructions are surrounded with many dangers, when entrusted to the care and superintendence of incompetent persons. In such hands there invariably exists a want of proportion in the formation of iron vessels, which exhibit defective powers of resistance, and such other abnormal conditions as might prove destructive to the efficiency and ultimate security of the structure. It is of importance to take into account the forms or lines of least resistance, such as a fine entrance at the bows, and an equally clear run at the stern, if high speed is to be obtained. The forms advantageous for vessels navigating rivers and smooth water are not so in those intended for long sea-voyages, and having to contend with the waves of the Atlantic. It is questionable, in the latter, whether or not some slight sacrifices should be made to speed, and some modification effected in the form of the bows and stern, in order to meet all the requirements of a safe and convenient vessel intended for the double purpose of carrying passengers and cargo. The safety and success of a vessel do not depend so much on its speed as upon its sea-going properties and sound construction. If, for example, we take one of the present iron clippers, with her sharp bows and fine proportions, I am of opinion that she is neither the safest nor the best description of vessel to contend with a heavy sea in foul weather.

In the first place, she is a diver, which cuts into the sea and rises with difficulty from a bath, which covers her decks with water as she pitches from sea to sea. Repeated immersions of this kind are exceedingly uncomfortable to those on board, and cause the ship to lift some tons of water before her buoyancy is restored to meet the next and every other succeeding wave into which she plunges in a rolling sea. I think it is the duty of every ship-builder to approximate as closely as possible to the lines of least resistance, which, in my opinion, ought to be carried to the utmost limits in smooth water, but in smooth water only. It may not be out of place to suggest that all passenger and emigrant ships should be modified in their construction, so as to give increased displacement at the bows and stern, but more particularly at the bows, where they require buoyancy, having to encounter the force of a large body of water rushing over them and scouring the decks from stem to stern. For several years I have endeavored to impress upon the minds of naval architects the necessity of increased strength on the upper deck of sea-going vessels, in order to balance the forces of tension and compression, and the double bottoms on the cellular principle of construction. The ultimate strength of a vessel is the resistance of its weakest part, and this being the case, it is evident that it is of little or no value to have a strong double bottom if the deck is liable to be torn asunder by the alternate strains of a vessel pitching at sea. That these strains, often repeated, lead to fracture does not admit of a doubt, and it has been proved by experiment, that, under these circumstances, time is the only element in the endurance of the structure; and this varies according to the intensity with which the strains are produced. I am convinced that heretofore the decks have been the weakest parts, and that several iron vessels have broken right in two from the constant working of alternate strains at midships along the line of the decks."

HYDRAULIC-LIFT GRAVING-DOCK.

Mr. Edwin Clark has described to the Institute of Civil Engineers the plans adopted by him at the Victoria (London) Graving-Docks. The principle of these docks is to provide a single lifting pit, out of which the vessels may be raised bodily on pontoons, which afterward float them in shallow water to a convenient berth for graving purposes. The ships are raised by hydraulic presses, the idea of which appears to have been derived from the presses employed in raising the Britannia and Conway Tubular Bridges, designed under Mr. Clark's superintendence. At the Victoria Docks, the depth of water in the lift-pit is twenty-seven feet; that over the rest of the dock is only six feet. In raising a vessel, one of the pontoons is brought over the lift-pit, filled with water, and sunk. The vessel is then floated in over the pontoon, and the pontoon and vessel raised together by the hydraulic presses. When at a sufficient altitude, the water is drawn off from the pontoon, which then floats the vessel to its berth in the shallow water. The whole operation of lifting occupies only about half an hour,

and the lifting-pit is then ready for the reception of another vessel. At the Victoria Docks there are thirty-two presses, with ten-inch rams, having a stroke of twenty-five feet. This, with a water pressure of two tons per circular inch, gives a total lifting power of 6,400 tons, less the weight of crossheads, rams, etc., amounting to six hundred and twenty tons. — *Popular Science Review, April*, 1866.

CORK SPRINGS.

The use of cork instead of India-rubber as a support for freight cars and similar heavy vehicles, would not, *a priori*, seem very promising, from ordinary impressions of its properties. The cork used for such springs is of the commonest description, harsh, hard, and full of fissures; it is cut into disks of about eight inches diameter, each pierced with a central hole. Previous, however, to cutting, it is soaked in a mixture of molasses and water, which gives it some softness, and renders it permanently moist. A number of these cork disks are placed in a cylindrical cast-iron box, a flat iron lid or disk is placed over them, and by hydraulic pressure is forced down so as to reduce the thickness to one-half. A bolt is then run through box, corks, and cover, at the centre, and a nut being screwed on this holds all in place, when the press is relieved, and the box of compressed cork, disks, or cork spring, is ready for use. One of these springs, placed in a testing machine, under a weight of 20,000 pounds, showed an elasticity suggestive of compressed air in a condensing pump. One would expect, from the appearance of the material, that, under heavy pressure, it would be pulverized or split into shreds, especially if this pressure was assisted by violent shocks; but, in fact, no such action takes place. A pressure which destroys India-rubber, causing it to split up and lose its elasticity, leaves the cork unimpaired; and, with the machinery in use, it has even been impossible, with any pressure attainable, to injure the cork, even when areas of but one inch were acted upon. — *Journal of Franklin Institute, May*, 1866.

ON THE PRESERVATION OF WOOD, IN DAMP AND WET PLACES.

In 1846, 80,000 sleepers of the most perishable woods, impregnated, by Boucherie's process, with sulphate of copper, were laid down on French railways: after nine years exposure, they were found as perfect as when laid. We would suggest washing out the sap with water, which would not coagulate its albumen: the solution would appropriately follow. Both of the last named processes are comparatively cheap; it costs less than creosoting, by one shilling per sleeper. The unpleasant odor of creosote is greatly against its use for lumber for dwellings; pyrolignite of iron is offensive, and also highly inflammable; the affinity of the chlorides for water keeps the structure into which they are introduced wet, and they also corrode the iron-work. Sulphate of copper is free from these objections, and is cheaper than the chlorides, and seems preferable for protecting wooden structures

against dry rot in damp situations, like mines, vaults, and the basements of buildings.

The surface of all timber exposed to alternations of wetness and dryness gradually wastes away, becoming dark colored or black. This is really a slow combustion, but is commonly called wet rot, or simply rot. Other conditions being the same, the most dense and resinous woods longest resist decomposition. Hence the superior durability of the heart wood, in which the pores have been partly filled with lignin, over the open sapwood; and of dense oak and lignumvitæ over light poplar and willow. Density and resinousness exclude water; therefore our preservatives should increase those qualities in the timber. Fixed oils fill up the pores and increase the density; the essential oils resinify, and furnish an impermeable coating; but pitch or dead oil possesses advantages over all known substances for the protection of wood against changes of humidity. According to Professor Letheby ("Civil Engineers' Journal," vol. 23), dead oil, 1st, coagulates albuminous substances; 2d, absorbs and appropriates the oxygen in the pores, and so protects from eremacausis; 3d, resinifies in the pores of the wood, and thus shuts out both air and moisture; and 4th, acts as a poison to lower forms of animal and vegetable life, and so protects the wood from all parasites. These properties specially fit it for impregnating timber exposed to alternations of wet and dry states, as, indeed, some of them do for situations constantly damp and wet. Dead oil is distilled from coal tar, of which it constitutes about .30, and boils between 390° and 470° Fahr. Its antiseptic quality resides in the creosote it contains. One of the components of the latter, carbolic acid (phenic acid, phenol) $C^{12} H^6 O^2$, the most powerful antiseptic known, is able at once to arrest the decay of every kind of organic matter. Professor Letheby estimates this acid at one-half to six per cent. of the oil. Bethell's process subjects the timber and dead oil, enclosed in huge iron tanks, to a pressure varying from one hundred to two hundred pounds per square inch, about twelve hours: from eight to twelve pounds of oil are thus injected into each cubic foot of wood. Lumber thus prepared is not affected by exposure to air and water, and requires no painting. Four pence the cubic foot is estimated as the probable expense of this process.

Though we have not to guard against decay, when timber is constantly wet in salt water, the *Teredo navalis*, a mollusk of the family *Tubicolaria* (Lam.) soon reduces to ruin any unprotected submarine construction of common woods. None of our native timbers are exempt from these inroads. The teredo never perforates below the surface of the sea-bottom, and probably does little injury below low-water mark; its food is the borings of the wood. Poisoning the timber does not protect from the teredo, the constant motion of sea-water soon diluting and washing away the small quantity of soluble poison with which the wood has been injected. Thorough creosoting the wood, with ten pounds of dead oil per cubic foot, is a complete protection against the teredo.

Another destroyer of submarine wooden constructions is *Limnoria terebrans*, another mollusk, resembling the sowbug. It pierces the hardest woods, and its perforations seem merely to serve as the animal's dwelling-place. The only successful protection seems to be the mechanical one of studding the surface thickly with broad-headed iron nails; oxydation rapidly fills up the interstices between the heads, and the outside of the timber becomes coated with an impenetrable crust, so that the presence of the nails is hardly necessary.—*Journal of the Franklin Institute, Nov.*, 1866.

METRICAL SYSTEM OF WEIGHTS AND MEASURES.

The subject of a decimal system of measure resolves itself into two parts,—the desirability of a decimal system, and the standard of measure to be adopted as the unit; the first of which may now be considered settled, and the principle definitely adopted in this country, the use of decimal measures being now legalized by a recent act of Parliament. But the second part of the subject, the standard of measure, is still open, and is of very great importance; the consideration of it involves two preliminary scientific questions, and two practical conditions to be fulfilled.

In respect to the first scientific question,—as to the standard that can be replaced best in case of being lost,—there is no real choice between the metre and the inch; for the metre having been originally determined by measuring part of a quadrant of the earth's circumference, its length was also referred to the seconds pendulum for facility of repeating the measurement; and the inch being obtained from the seconds pendulum, both the metre and the inch are thus verified by the same means: indeed, the relation between them being once established, any means of verification is equally available for both. In regard to the second scientific question,—as to the standard that is most universal in the character of its basis,—the supposed advantage of the metre, as an even fraction of the quadrant, has been proved by the results of more accurate measurement to be a mistake, its actual length being an uneven fraction of the quadrant, just as the inch is an uneven fraction of the pendulum; and the length of the quadrant itself being different in different longitudes, there is therefore no choice between the metre and the inch, in respect of universality of its basis. The present legal standard of measure in this country is an individual metallic yard measure, independent of any reference to another source; and the metre is similarly a continuation or copy of an original standard metre which is now known to differ from the exact measure that it was intended to represent of the quadrant. There is no practical advantage, however, as regards accuracy, in depending upon copying for the preservation of a standard; for, by Mr. Whitworth's process of contact measurement, the accuracy in copying lengths can now be carried as far as one millionth of an inch, which is a higher approximation than can yet be attained in measuring the length of a pendulum or an arc of the earth's circumference.

The first practical condition to be fulfilled by the standard of measure is that it shall be the one best suited for use in decimal subdivision; and this point is to be determined by the relative practical convenience or inconvenience of its principal subdivisions and multiples. In connection with mechanical engineering work, the inch has a special qualification for the standard of measure, since its subdivisions and multiples predominate in the dimensions of the parts of machinery; it is the basis on which the various machines and engines made in this country have been constructed, and on which are founded calculations of strength of materials, sectional areas, steam pressure, power, velocity, capacity, and weight; so that the mechanical engineer may be said to think in inches, calculate in inches, and work in inches. For the classes of work in which the finer measurements are required, such as rifle-bores, wire and metal gauges, etc., the desired degree of accuracy is readily and conveniently expressed in thousandths of an inch; whilst the millimetre, the smallest subdivision of the metre-scale, not being smaller than the one-twenty-sixth of an inch, requires the addition of two places of decimals to give the same degree of accuracy. This is a practical advantage of importance in favor of the inch as the unit of measure, since dimensions to one-thousandth of an inch are now required in regular use in mathematical work. Moreover, by taking as the unit the lowest of the present denominations,—the inch,—any longer dimensions on the present scale can be exactly expressed in the decimal system without fractional remainders. The second practical condition attaching to the standard of measure is that it shall be the one most extensively in use already, so as to involve the least alteration of existing measures; and, in addition to a preponderance in the population now using the inch over that now using the metre, the former includes the great machinery producers, whose work already exists in such large quantities in all parts of the world, in the form of engines, machinery, railway plant and tools; and the difficulties in the way of a change to the metre in this country appear, therefore, so insuperable, as to amount practically to a prohibition of a decimal system, if it is to be based on the metre.

For larger dimensions, the most convenient decimal change would be the adoption of a ten-inch foot; and the larger measures being already multiples of the inch, their decimal adaptation to the inch would be at least easier than their entire alteration to the metre standard. It is also very desirable that the present weights and measures of capacity should be reduced to decimal systems; and it is considered that they can practically be based as readily upon the inch, as the standard of measure, as upon the metre, in the same way as with the definition of the metre or the inch.

In a discussion which followed the reading of this paper, the metre as the standard unit of decimal measure, in preference to the inch, was advocated by a deputation from the International Decimal Association, who concurred in considering that the question of the standard of measure depended upon the fulfilment of the practical condition which had been stated; that the standard should be the

one best suited for use in decimal subdivisions, and the one most extensively adopted already. As regarded decimal subdivision, the results of inquiries made by the Association had led them to recommend the metre as adapted for the greatest variety of measurements, and for the most numerous cases likely to occur in daily life, and to conclude that the inch did not in itself offer any advantage above the metre, even to mechanical engineers, since accuracy of measurement depended not on the scale, but on the measuring instrument employed, which ought to be applicable to any scale; and the millimetre had been already tried to some extent in this country, and was found convenient and suitable for mechanical work. In reference to the extent of population adopting the metre or the inch, it was believed that the numerical preponderance was already in favor of the former, and was steadily increasing by the more general adoption of the metre in other countries; and the simplicity and convenience of the metre system, both for measures and weights, were urged, together with the great importance of facilitating international communications, which were now so much interfered with by the incongruity of the systems in use. — MR. JOHN FERNIE, *of Leeds, in London Mechanics' Magazine, February*, 1865.

At the meeting of the National Academy of Sciences, held in Washington, D. C., in January, 1866, the Committee on Uniform Weights, Measures, and Coinage, made the following report, which was adopted by the Academy, and ordered to be communicated to the Treasury Department, and to the Congressional Committee having charge of the same subject: "The committee are in favor of adopting ultimately a decimal system, and in their opinion the metrical system of weights and measures, though not without defects, is, all things considered, the best in use. The committee therefore suggest that the Academy recommend to Congress to authorize and encourage by law the introduction and use of the metrical system of weights and measures; and, with a view to familiarize the people with the system, the Academy recommend that provision be made by law for the immediate manufacture and distribution to the custom-houses and States of metrical standards of weights and measures; to introduce the system into the post-offices, by making a single letter weigh fifteen grains instead of fourteen and seventeen-hundredths, or half an ounce; and to cause the new cent and two-cent pieces to be so coined that they shall weigh respectively five and ten grams, and that their diameter shall be made to bear a determinate and simple ratio to the metrical unit of length."

CONVERSION OF CAST-IRON INTO STEEL.

M. Galy-Cazalat, as reported in the "London Chemical News," No. 320, has communicated a new process for quickly and economically converting any mass of cast-iron into steel, which he accomplishes by passing superheated steam into the fused iron. In traversing the mass the steam is decomposed; the oxygen burns progressively the carbon and oxide of iron, while the hy-

drogen combines with and removes the sulphur, phosphorus, and other metalloids which render the steel brittle. When the color of the flame at the top of the mass indicates a proper amount of decarburation, the steel is run out. He operates either in a cupola or a reverberatory furnace of his own construction, in which the waste heat from the furnace is utilized to produce the steam. There has always been a difficulty in knowing when to stop the decarburating current, the process often being carried too far; but this author says common steel can always be regularly produced by completely decarburating the cast-iron and then adding ten per cent. of spathic cast-iron, which restores to the iron the amount of carbon necessary to effect the conversion into steel. By a peculiar contrivance, the author shuts off the current of superheated steam from the metal and passes it into the chimney, where it serves to increase the draft, and thus leaves the steel in a state of tranquil fusion for about fifteen minutes, by which he gets a perfectly homogeneous mass. To remove bubbles in his castings he has a very ingenious device. A cannon, for example, being cast, while the metal is still hot and soft, he covers the mould hermetically with a sort of hat, from the top of which rises a pipe, in which is placed six or ten grammes of a mixture of eighty parts of saltpetre and twenty parts of charcoal. By opening a stopcock the powder is allowed to fall on the metal, where it gets ignited, producing a large quantity of gas which exerts pressure on all parts of the casting, removing the bubbles and increasing the tenacity of the metal.

HARD AND TUNGSTEN IRON.

M. Gaudin reports, that while experimenting in an ordinary cupola furnace, by melting iron at a very high temperature with phosphate of iron and peroxide of manganese, he succeeded in obtaining a species of iron, very hard and forgeable, but turning well, and applicable to the manufacture of pieces which require great strength and hardness. The metal is remarkably sonorous, and might perhaps be applied to the casting of bells. A still harder metal may be produced by the addition of tungsten to ordinary cast-iron; this tungsten-iron is said to surpass everything previously known as a material for cutting rocks, and that crystals of it will cut glass as easily as the diamond.—*Jour. Soc. Arts, No.* 685, 1866.

SEPARATING PHOSPHORUS FROM METALS.

It is well known that phosphorus is a substance which prevents the production of pure qualities of iron and other metals, and all attempts to remove the same have hitherto failed. Mr. Carl H. L. Wintzer, of Hanover, has found that chlorine gas and chloride of calcium are adapted to obtain the desired result. Chlorine gas, as a simple element, does not decompose, and chloride of calcium is the only combination thereof, which, at the different

degrees of temperature which occur in practical metallurgy, neither volatilizes nor decomposes unless another agent be introduced. Other known combinations of chlorine, as chloride of magnesium, decompose even at the boiling-point of water; chloride of sodium becomes volatile at a comparatively low temperature.

Mr. Wintzer therefore employs chlorine gas and chloride of calcium for the removal of phosphorus, in processes of melting ores and in the treatment of metallurgical products. He makes use of this gas and the salt in blast furnaces, as well as in the process of puddling, refining, and re-casting, and in any kind of furnace and in all processes of melting, applying the gas direct or adding the prepared salt (chloride of calcium) in any convenient form; or, employing solutions containing muriatic acid, with the simultaneous use of lime or calcareous substances, by which process chloride of calcium is formed at the moment of its application. Through the effect of chlorine gas and chloride of calcium on phosphatic ores and metals, volatile combinations of phosphorus are formed, and thereby the phosphorus is removed. The process is as follows: In smelting an ore of iron or other metal containing phosphorus as an impurity, the operator charges into the smelting-furnace, with the ore, chloride of calcium, in the proportion of from five to twenty-five parts, by weight, for each part of phosphorus found by analysis to be contained in the ore; and, in other respects, the smelting operation, is conducted in the ordinary manner. The resulting metal will be found much more free from phosphorus than if the ore had been smelted without the addition of chloride of calcium. In place of adding the chloride of calcium direct, lime and muriatic acid may be mixed separately with the ore, or may be otherwise applied in combination. It is more convenient, however, to employ chloride of calcium ready formed. Or, in place of employing chloride of calcium, chlorine gas may be used; the gas may be mixed with air and forced as a blast through the ignited charge in the furnace, or the gas itself may be blown through the melted metal after it is tapped out of the furnace. The quantity of chlorine thus applied should be from three to fifteen times the weight of the phosphorus contained in the ore or metal. Chloride of calcium or chlorine may be applied in a similar manner when remelting iron or other metals, when it is desired to separate phosphorus therefrom. Phosphorus can thus be separated from all metals to which a strong red heat can conveniently be applied; more especially, however, it is applicable to the treatment of iron and copper.—*Mechanics' Magazine.*

PURIFICATION OF IRON FROM PHOSPHORUS AND SULPHUR.

According to Dr. Adolphe Gurt, of Bonn, Prussia, iron may be purified from phosphorus by means of silica. He asserts that if, in smelting phosphoriferous iron ores, enough silica be included in the furnace-charge to form a highly silicious slag, the phosphorus contained in the ore will have its condition changed from the

crystalline state, in which, he says, "it exists originally in the ore, to an amorphous state, in which it is readily eliminated from pig-iron during conversion either into malleable iron or into steel." The same gentleman alleges that iron may be entirely freed from sulphur by means of lead. The lead "may be applied," he says, "either to pig-iron which is to be puddled, either before or during the puddling process; or to iron which is to be refined, or in process of being refined, in common refinery furnaces, or in reverberatory furnaces; or to pig-iron for casting; or to iron to be treated by the pneumatic process, for the production of either homogeneous iron or steel; or to the materials used in making cast-steel by the pot or other process of melting." In any case the lead is to be added to the iron while the latter is in a molten state, and is to be "brought by any suitable means as much as possible into contact with the whole of the melted iron."—*Mechanics' Magazine.*

ON SODIUM AMALGAMATION.

Mr. Henry Wurtz publishes, in "Silliman's Journal" for March, 1866, a communication on the process of sodium amalgamation, discovered and patented by himself, which is of great practical value in metallurgy and the arts. His invention consists in imparting to quicksilver a greatly enhanced adhesion, attraction, or affinity for other metals and for its own substance, by adding to it a minute quantity of one of the highly electro-positive metals sodium, potassium, etc. It is applicable in all arts and operations in which amalgamation by quicksilver can be made available to separate or extract gold, silver, or other precious metals from their ores — in all operations in which amalgamation by quicksilver, in conjunction with reducing metals, such as iron or zinc, can be made available in recovering metals from their soluble or insoluble saline compounds; such as silver from its sulphate, chloride, or hypo-sulphate; lead from its sulphate or chloride; gold from its chloride or other solution — in the mercurialization of metallic surfaces in general: for instance, in the amalgamation of the surfaces of zinc in voltaic batteries; of the surfaces of copper plates, pans, etc., used in the saving of gold from its ores — in the more convenient transportation of quicksilver, by the reduction thereof into solid forms.

From experiments made and reported by Prof. Silliman, this discovery has proved of great value in the extracting of gold from its ores. An interesting series of experiments with sodium-amalgam, in the treatment of auriferous ores, has been conducted under the superintendence of Prof. Silliman, and the results obtained have been highly satisfactory. He states that, having at his disposal a considerable quantity of California gold quartz from a mine in Calaveras county, he proposed to Mr. Wurtz to subject these ores to his method of amalgamation, under conditions subject to control, both as expressing the actual value of the material experimented on, as well as giving the value of the results and the loss in the process. The crushing and grinding was effected in the apparatus of Mr. Dodge, of New York; which, doing its work dry, gives unusual

facilities for exactness. The details obtained in these experiments, as to the degree of comminution reached by this apparatus, have been very carefully worked out, but are reserved for a future communication, having no bearing on the subject now before us, although believed to be of value to the art of ore-dressing. After detailing the several experiments which were actually concluded, Professor Silliman observes, that the experiments are still in progress, but the results show that, with unaided mercury, the gold saved is less than sixty per cent. of the whole quantity of gold known to be present. In one experiment less than forty per cent. was saved, while, by the aid of the amalgam of sodium the saving is increased to eighty per cent., or an increase of more than twenty per cent., leading to the reasonable expectation that, in the large way, at least eighty per cent. of the gold present in a given case may be saved, and, in many cases, where the gold is coarse and free, that even better results than this may be attained. The first experiment detailed, in which a different amalgamating apparatus was used, gave results surprisingly close. He does not think the barrel as good a form of apparatus for this description of amalgamation as some one of the numerous forms of pan now in use. It was employed in these experiments simply because it was a convenient means of treating small quantities of ore in making comparative experiments. Experiments in California, under his direction, have been set on foot upon a scale of magnitude adequate to test the value of this discovery, in the metallurgy of gold, in a satisfactory manner, the results of which may now be looked for at no distant day. With regard to the mode in which the sodium acts, Professor Silliman remarks that the action of the sodium in this case appears to be in a manner electrical, by placing the mercury in a highly electro-positive condition towards the electro-negative gold, seeming to give some reason for the term magnetic amalgam, adopted by Mr. Wurtz, as the trade-mark of the alloy. The quantity of sodium is entirely too small to allow of the supposition that it acts by its chemical affinities. It is well known to chemists that the metallic sulphides are decomposed by amalgam of sodium; but no one supposes that an inventor could be found so Quixotic in his chemical notions as to seriously propose the use of sodium amalgam as a means of effecting the reduction of the sulphides of silver, etc., since not less than one equivalent of sodium would be required to set at liberty one equivalent of silver. The use of the sodium amalgam for silver amalgamation must depend, if found really useful in the large way in the silver reduction process (which still remains to be proven), upon a like power of electrical action to that seen in its action on gold, and also on the well-known power of preventing the granulation (flouring) of mercury, or on saving the mercury when thus changed. Indeed, there is good reason for believing that a most important part is played by the sodium amalgam in this last particular. The amalgam of gold or silver is very liable, as every mill-man knows to his loss, to granulate and disappear from the plates of the battery, or from the riffles, after it has been formed. If this granulation

takes place, it is almost impossible, by the existing modes of amalgamation, to recover the minute particles which float off with the currents of water, and are lost. The action of the sodium in recovering the mercury which has passed into this condition is, perhaps, its most remarkable property. — *Mining Journal*, 1866.

SODIUM AMALGAM.

This is now likely to be superseded by a far less expensive, and, it appears, not less useful material. Caustic soda has not only been found quite as effective as sodium amalgam, but it is contested that the sodium in the amalgam actually assumes the form of caustic soda before producing its effect. A very simple experiment will show the efficiency of the soda. If a finely pulverized metallic powder is thrown into water, no amount of stirring will cause it to fall to the bottom of the vessel; it is rendered specifically lighter than the fluid by the coating of air which adheres to it. But if a very small quantity of caustic soda or potash is added, it will soon descend from the surface to the bottom. It is supposed that the minute particles of mercury also, and of gold, are prevented from coming into contact by a coating of air, which the alkali removes in a way not yet ascertained. The potash or soda must not be allowed to lose its causticity by exposure to the air, or it will be ineffective, having become a carbonate. — *Intellectual Observer, Sept.*, 1866.

SIMPLE MODE OF MANUFACTURING SULPHURIC ACID.

The necessity for large and costly leaden chambers has rendered the manufacture of sulphuric acid both troublesome and expensive. A method of producing it, in which the use of leaden chambers is dispensed with, not only greatly facilitates the process, but affords a product which possesses the important advantage of being altogether free from contamination by lead. Should it be found to answer for industrial purposes, it will constitute a very important improvement on the method so long in use. It consists in transmitting the acid fumes, formed in the ordinary way, through a series of earthenware cylinders, which are piled up and arranged in such a way as to form a number of columns, filled with coke, and communicating with one another. Straw is introduced into them as required; and the acid vapors being condensed by the coke, they trickle down into a reservoir placed beneath for the purpose of receiving them. The acid liquid thus obtained is concentrated in the usual way.

NEW SAFETY LIGHT FOR COAL MINES.

MM. Dumas and Benoit have been making some experiments in the French collieries on the application of electricity as an illuminating power in "fiery" coal mines. Voltaic electricity has been proposed on several occasions, as a means of giving light to

the collier in dangerous places; but, under the ordinary conditions, it has not been found practicable to employ it. Dumas and Benoit propose to apply Rhumkorff's coil machine and Geissler's tubes; to use, indeed, those tubes, with their beautiful auroral light, as a miner's lamp.

The tube, it is now generally known, is filled with some highly rarefied gas, and platinum wires are hermetically sealed into the ends. When the discharges from a Rhumkorff's coil apparatus are passed through this tube, it becomes filled with a mild, diffusive light, which lasts as long as the discharges pass through the rarefied medium. This light is unaccompanied by heat; it cannot, therefore, under any circumstances, explode the fire-damp of our coal mines.

This new "safety lamp" consists essentially of a cylindrical zinc vessel about six inches high and four inches in diameter, which encloses a porous vessel holding a cylinder of carbon. A solution of the bichromate of potash is placed within the porous cell, and dilute sulphuric acid without it. This battery is secured by a wooden cover, which is, by means of India-rubber packing, made to fit closely. Then there are a Rhumkorff's coil and condenser, and a Geissler's tube. This tube is arranged into a conical coil, so that a large surface of light is secured within a small space. Of course, the objection to this will be the cumbrous character of the machine and its adjuncts. Dumas and Benoit think they have answered this objection by the very ingenious arrangement which they have secured. We are assured that the weight of the glass case does not exceed two pounds, and that of the other parts of the apparatus is not more than twelve pounds. That there are many advantages in this electrical lamp cannot be denied. But we doubt if so delicate a machine can be entrusted to the hands of colliers. Under circumstances of danger, such a lamp as this would prove of the highest value. As Dumas and Benoit are making practical trials of their "cold light," as they call it, we shall, if they are successful, hear more of this interesting application.

The Institute of France has given the inventors a prize of one thousand francs for the ingenuity of their plan. We understand that some trials have been made in the Newcastle collieries. The objection raised by the miners is, that the light is a "glimmer,"—not a steady illumination.—*Reader.*

HYDRAULIC MACHINE FOR CUTTING COAL.

This machine, by W. E. Carratt, has now been at work for two years. It does not dispense with labor, but it performs the undercutting, which was a most laborious operation, either in the end or face of the coal, in a more efficient and economic manner than the miner can do it himself. By it the size of the coal is improved, the amount of slack reduced, and a single seam will yield more by one thousand tons of coal per acre, than when worked by hand-labor. The machine undercuts its "holes," or "kirves," with one man and one boy as attendants, and completes the work, with once going over, at the rate of fifteen yards per

hour. Each machine uses thirty gallons of water per minute, at about three hundred pounds pressure, according to the hardness of the substance to be acted upon. The machine, when in operation, fixes itself dead fast upon the rails during the cutting strike, and releases itself at the back or return stroke, and traverses forwards the requisite amount for the next cut without any manual labor. No percussive action results from the machine, either against the roof or into the coal, but simply a concentrated pressure, producing a steady reciprocating motion, at fifteen strokes per minute. There is, consequently, no dust nor noise, and little wear and tear. For the same reason, when cutting pyrites, the tools throw out no sparks, and the workmen can hear any movement in the coal or roof. The price of a machine, a working model of which is at the Industrial Exhibition, is stated to be £125.

STEAM FIRE-PROOF SAFE.

Rev. Rufus S. Sanborn, of Wisconsin, exhibited to the Massachusetts Institute of Technology, in December, 1866, and described a model of a steam fire-proof safe, of his invention. The nature of this invention consists in placing one or more boxes, or unfilled safes, one within the other, the outside case being filled or otherwise in the ordinary way, and these inner boxes detached from one another and the outside case by means of flanges or spurs, so as to form air-chambers all around said inside box or boxes, and into these air-chambers are inserted metallic vessels for holding water, with simple steam-valves, which will be opened so as to allow the steam to escape when the heat of the inside of the safe shall become sufficient for that purpose.

This steam saturates the air-chambers, and its surplus escapes by the doors, so as to keep the temperature of the inside of the safe about that of boiling water, in which temperature none of the papers of the inside box can either burn or char so long as any steam can be maintained.

By a peculiar arrangement of a succession of these vessels, one exhausts after another, and thus for a long time there is the most complete protection, in addition to the other protection which the filling and air-chambers afford. He gave a history of the experiments which had led to the above result, and stated that the safe was soon to have a public trial. In an ordinary-sized safe, the moist filling would save an hour in absorbing heat before the heat could penetrate to the interior. Such a safe would hold fifteen gallons of water, which, under the arrangement described, would take a very long time for the entire escape of the steam.

At a trial held soon afterward, this safe was submitted to a heat so intense as to melt the knobs on the door, and was kept externally red hot for nearly four hours: papers in the interior were taken out entirely uninjured, and only a gill of water vaporized; while those in a safe by one of the best makers, submitted to the same trial, were badly charred, as well as the whole interior woodwork, and in another hour would have been destroyed.

A REMARKABLE SOLVENT.

It is now discovered, it appears, that if a piece of copper be dissolved in ammonia, a solvent will be obtained, not only for lignine, the most important principle of all woody fibre, such as cotton, flax, paper, etc., but also for substances derived from the animal kingdom, such as wool and silk. By the solution of any of these, an excellent cement and water-proofer is said to be formed; and, what is equally important, if cotton fabrics be saturated with the solution of wool, they will be enabled to take the dyes, such as the lac dye and cochineal, hitherto suited to woollen goods only. Hydriodide of ammonia, we may also observe, was not long since discovered to be an equally remarkable solvent of the most refractory, or, at least, insoluble mineral substances. Now it is an interesting circumstance that ammonia, according to Van Helmont, and other old chemists and alchemists, was one of the requisite materials in the formation of the "alkahest," or "universal solvent," of the ancient sages.

THE MAGNESIUM LAMP.

A lamp for the purpose of burning the wire has been invented by Mr. A. Grant. He seeks to make magnesium cheaper than the best stearine, and states that by burning a strip of zinc in conjunction with two strips of magnesium, he is able to reduce the cost of the light two-thirds. He even predicts that magnesium will become as cheap as zinc, and that in the course of time it will be possible to illuminate a street a mile long at the rate of a halfpenny an hour. It is not a small thing to be able to record that photography is no longer dependent upon the action of the sun. The value of magnesium as an illuminator for the purpose of "signalling" is obvious. The portable nature of the contrivance, and its perfect immunity from risk of explosion, together with some other evident advantages, render its vivid light all the more practically valuable. It may be used with advantage on the stage. — *Civil Engineers' and Architects' Journal, Jan.*, 1865.

Four wires, weighing three grains per foot, each burning at the rate of eight inches per minute, or eight grains in that time, give a light equal to two hundred and eighty-eight sperm candles, or twenty-one and one-quarter Argand gas-burners. At this rate of consumption, one ounce of wire, costing six dollars and fifty cents, would last an hour. — *Franklin Journal, Nov.*, 1865.

Several arrangements have been devised, more or less ingenious, to burn the metal in the form of wire or ribbon; but the great difficulty in all such arrangements has been, that it required clockwork to feed it forward. In order to avoid this difficulty, Mr. Larkin, after many trials, has succeeded in constructing a magnesium lamp, a specimen of which we describe. The distinguishing peculiarity of these lamps is, that they burn magnesium in the form of powder, instead of ribbon or wire; and that they do not depend on clockwork or any similar extraneous mo-

tive-power for their action. The metallic powder is contained in a large reservoir, having a small orifice at the bottom, through which the powder falls simply by its own gravity, like sand in an hour-glass. In order that a sufficient orifice may be used, and to facilitate the steady flow of the powder, it is mixed with a quantity of fine sand or other diluting material, the proportion of powder to sand being varied according to the amount of light required. After leaving the orifice of the reservoir, the stream of metallic powder and sand falls freely through a metal tube, into the upper end of which a small stream of ordinary gas is also introduced. The mingled streams of powder and of gas thus flow down the tube and escape together at its mouth, where they are ignited, and continue burning with a brilliant flame as long as the supply of gas and metal is maintained. As the metal becomes consumed, the sand with which it was mixed falls harmless into a receptacle provided for it, while the fumes are entirely carried away by a small tube-chimney into the outer atmosphere. Immediately below the orifice, there is a valve, to either regulate the quantity, or entirely arrest the flow of the metallic powder, which valve may be opened and shut at pleasure. When it is desired to light the lamp, the gas is first turned on, just sufficiently to produce a very small jet at the mouth of the tube, which small jet, being once kindled, may be allowed to burn any convenient time, until the moment the magnesium light is required. All that is then needed is to turn on the metallic powder, which instantly descends and becomes ignited as it passes through the burning gas. This action of turning on and off the metallic powder may be repeated, without putting out the gas, as often and as quickly as desired; so that, in addition to the ordinary purposes to which lamps are applied, an instant or an intermittent light of great brilliancy, suitable for signals or for light-houses, may be very simply produced with certainty of effect, and without the smallest waste of metal. Mr. Larkin explained that the lamp could be made to suspend from the roof, in place of an ordinary gas sunlight, and arrangements could also be made for its use in signals and for light-houses. The greatest difficulty was the price of the metal; but only about four years had elapsed since the production of the metal in any quantity by Mr. Sonstadt, and the demand for it hitherto had been a fancy one. Mr. Larkin said that the cost of burning magnesium in the lamp which he exhibited would, at its present price, be about £1 an hour, and that no difficulty whatever was experienced in reducing the magnesium to powder. — *British Association Report*, 1866.

PARAFFIN FOR WATER-PROOFING.

About three years ago, Dr. Stenhouse took out a patent for rendering leather and various textile and felted fabrics water-proof, by means of paraffin; it was found, however, that paraffin alone, especially when applied to fabrics, became, to a considerable extent, detached from the fibre of the cloth after a short time, owing to its great tendency to crystallize. The presence, however, of

even a small quantity of drying-oil causes the paraffin to adhere much more firmly to the texture of the cloth, from the oil gradually becoming converted into a tenacious resin by absorption of oxygen. Paraffin is now first melted with the requisite quantity of drying oil and cast into blocks; it can then be applied to fabrics, by rubbing them over with a block of it, either cold or gently warmed; or the mixture may be melted and laid on with a brush, the complete impregnation being effected by subsequently passing it between hot rollers. When applied to cloth thus, it renders it very repellant to water, though pervious to air. Cloth paraffined in this manner forms an excellent basis for such articles as capes, tarpaulins, etc., which require to be made quite impervious by subsequently coating them with drying-oil, the paraffin, in a great measure, preventing the injurious influence of drying-oil on the fibre of the cloth. The mixture can also be very advantageously applied to the various kinds of leather; one of the most convenient ways of effecting this is to coat the articles with the composition, and then to gently heat them until it is entirely absorbed. When leather is thus impregnated, it is not only rendered perfectly water-proof, but also stronger and more durable; boots and shoes are rendered very firm without losing their elasticity; it therefore not only makes them exceedingly durable, but does not interfere with their polish, which, on the whole, it rather improves. The superiority of paraffin over most other materials, for some kinds of water-proofing, consists in its comparative cheapness, in being easily applied, and in not materially altering the color of fabrics, which, in the case of light shades and white cloth, is of considerable importance. — *Practical Mechanics' Journal, April*, 1865.

LINOLEUM MANUFACTURE.

The manufacture of this new and interesting material, which threatens to rival the India-rubber trade in the multiplicity and utility of its application, is based on the invention of Mr. Frederick Walton, whose patents are now worked by the Linoleum Manufacturing Company at Staines, and 45 Cannon Street, West. The word linoleum is derived from *linum* (linseed) and *oleum* (oil), from which products the new substance is made. The linseed oil of commerce is solidified or "oxydized" by the absorption of oxygen, by which process it becomes changed into a semi-resinous substance. It is then combined, at a strong heat, with resinous gums and other ingredients; and the substance thus obtained has all the appearance and many of the properties of India-rubber.

Those who are conversant with the uses of the pliable elastic gums readily perceive the wide field of usefulness that any material possessing such properties is designed to occupy, more especially as the price of the new substance is much lower than India-rubber or gutta-percha. Linoleum can also be dissolved into a varnish or cement in the same manner as India-rubber, and in this form can be employed in the manufacture of material for

water-proof clothing. As a varnish or paint for protecting iron or wood, or for coating ships' bottoms, it is said to be admirably adapted, as it dries rapidly, in fifteen or twenty minutes, and adheres with singular tenacity. As a cement for uniting substances, such as wood with iron, or wood with wood, it is very effective, and has similar properties to the marine glue made from India-rubber and shellac. Singularly enough, linoleum can also be vulcanized or hardened by exposure to heat. By this means it is made as hard as the hardest woods, and rendered capable of receiving a high polish without the aid of varnish or any other extraneous substance. In this condition it can be filed, planed, or turned as easily as wood, and employed in many of the various ways for which wood is used. Or it can be moulded in heated dies to any desired form, as, for example, flax-spinners' bosses, sheaves for ships' blocks, surgical-instrument handles, picture frames, mouldings, veneers to imitate marble, ivory, ebony, and other woods. Combined with emery, it forms a grinding-wheel having extraordinary cutting or abrasive power. Very dissimilar are some of the uses to which the new substance can be applied. Carriage-aprons, cart-sheeting, sail-covers, reticules, tarpauling, printers' blankets, gas-pipes, telegraph supports, washable felt carpets, table-covers, paints for carriages or for printing floor-cloth, or enamels of any color for enameling papier-maché or metals. These are only some of the many uses to which linoleum may be applied.

The manufacture has, however, hitherto been chiefly confined to the development of the floor-cloth trade, for which the new material has proved itself well adapted. Linoleum floor-cloth is produced by combining the linoleum with ground or powdered cork, which is rolled on to a stout canvas, the back of the canvas being afterward water-proofed with a cement or varnish made from the solidified or oxydized oil, before referred to. The combined fabric so manufactured is then printed by means of blocks, in every variety of pattern, in the ordinary way. The floor-cloth thus produced is pliable, and comparatively noiseless to walk upon. It washes well, preserves its color, and can be rolled up like any ordinary carpet. Besides being very durable, — the component parts being almost indestructible except by fire, — it will not decompose by heat or exposure to the sun or air, as is the case with India-rubber. It is therefore better adapted than that substance for hot climates. To the chemist, engineer, and manufacturer, linoleum offers quite a new substance for experiment; and, no doubt, as it becomes better known, the various uses to which it may be applied will be more fully developed and appreciated. The patentees, we understand, are prepared to grant licenses for the manufacture of some of its applications, such as varnishes, cements, and the hard compounds above mentioned. Important results may, therefore, follow the introduction of this new and valuable substance." — *Mechanics' Magazine.*

PARKESINE.

While considerable attention is being given to gun-cotton and nitroleum, a somewhat similar substance is gradually making its way as an article of ordinary domestic use, entirely free from danger, and possessing such advantages as are likely to secure its general adoption. In the manufacture of Parkesine, fibrous vegetable matter of any and every kind — cotton and flax waste, and old rags, being, from their cheapness, the favorite materials — may be employed. These are first dissolved by acids, and they then yield what chemists call pyroxyline. Pyroxyline, however, as its name implies, is highly inflammable, and indeed explosive, like gun-cotton; and this dangerous qualification has to be neutralized. Mr. Parkes effects this by the introduction of either of various chemical ingredients, as iodide of cadmium, tungstate of soda, chloride of zinc, gelatins, several carbonates, sulphates, and phosphates. Collodion (as used by photographers), when evaporated so as to leave a solid residue, has been employed in the production of Parkesine; but it was found by far too expensive. The substances which have given the best results with the pyroxyline are nitro-benzole, aniline, and glacial acetic acid. By the use of various proportions of these substances, all consistencies of Parkesine, from the solid to the fluid form, may be obtained. The applications of Parkesine are, of course, as numerous as its forms are various. In the fluid form, it is available for waterproofing fabrics; and in this way it is very serviceable. In a plastic state, Parkesine is useful in making tubes, etc., and for insulating telegraph wires. Where hardness and toughness are required, these desiderata are arrived at by the admixture of oils prepared with chloride of sulphur, which latter solidifies and makes them (the oils) non-adhesive. Again, by the use of resins, gums, stearin, tar, etc., modified preparations of the invention may be made to suit special applications. Parkesine, indeed, is a most accomodating material; and may be made as hard and brittle as glass, or as fluid and yielding as cream, and of every intermediate consistency. It may have elasticity imparted to it to almost any extent or degree, and in this state it is likely to become a dangerous rival to India-rubber and gutta-percha, inasmuch as it will become, if it be not now, far cheaper than those useful articles of commerce, and answer almost all their uses equally well. Vulcanized India-rubber will find a sturdy competitor in Parkesine, for it may be manufactured with less of brittleness, quite as much hardness, and at a lower cost than that tediously manipulated substance. There is no refuse in the manufacture, the chips and cuttings being capable of re-manufacture with the greatest facility. Parkesine will take any color, and may be given any degree of hardness; it may be made to imitate tortoise-shell, marble, malachite, or amber; and can be cut with a saw, turned in the lathe, planed, carved, engraved, stamped between dies, rolled into thick or thin sheets, worked into screws, shaped into mouldings or cornices, etc. It is susceptible of a high polish, agreeable to the touch, and not disagreeable in smell. At a tem-

perature of 340° Fahr., it is consumed, without flame, being decomposed and passing off as dense smoke, leaving but a dark colored ashy residue behind. It is now being manufactured for a variety of purposes, and is daily becoming more extensively known.—*Mining Journal.*

At the 1865 meeting of the British Association, Mr. Owen Roland read a paper on Parkesine. This substance derives its name from its inventor, Mr. Alexander Parkes, of Birmingham, Eng. It is used for a great variety of purposes, and possesses properties akin to gutta-percha and India-rubber, and may be made easily into any shape and of any color. Gun-cotton is used in its manufacture as a basis; but many other materials are also introduced, solvents, oils, cotton-waste, etc. Cotton, not readily explosive, is the most desirable; chloride of zinc is also used to prevent rapid combustion. The solvent, invented by Mr. Parkes is applicable chiefly for India-rubber solutions, gutta-percha, and a number of gums. The several varieties of Parkesine are made by mixing these substances in definite proportions. Mr. Roland considered it more valuable as an insulating material than India-rubber, gutta-percha, or any other combination hitherto used for this purpose. It is enormously strong, being capable of supporting a mile of its own weight, while it possesses the great qualification of being joined, in case of fracture, with a strength equal to the original substance. It is not affected even by acids; and immersion in sea-water four years did not deteriorate its qualities. In dry heat, at 212° Fahr., it remains electrically perfect, and it is not softened at even a higher temperature.

INDIA-RUBBER FOR MARINE CABLES.

At the Nottingham (1866) meeting of the British Association for the Advancement of Science (Section of Physical Science), Mr. Hooper read a paper on the electrical and mechanical properties of his India-rubber for submarine cables. He reduces the general coatings of India-rubber by means of heat to one perfectly homogeneous coating, separated by a film of vulcanized India-rubber. The advantages claimed are, durability and resistance to mechanical injury, permanency of insulation at high temperatures, impermeability under long immersion and pressure in water, freedom from defects in manufacture, and high state of insulation with diminished induction. One hundred and fifty miles of this wire have been sent to India, and the insulation per nautical mile is about forty times better than that of the Persian Gulf core.

PAPER FROM WOOD.

The manufacture of white paper from wood is now quite a success at the Manayunk Wood-pulp Works, Pennsylvania. The wood used is that of the *Liriodendron tulipifera*, Linn., in Tulip poplar, and *Abies canadensis*, Michx, or Hemlock spruce. It is brought to the works as ordinary cord-wood, and is cut into chips by means of two immense machines having cutters attached to

rotatory discs, capable of cutting thirty to forty cords of wood in twenty-four hours. These chips are conveyed in wagons to the boiling-house, and placed in boilers, where the reduction to pulp is effected. The pulp thus reduced is then conveyed to pulp-engines, is worked in these engines, and run through cleaning-machines. From the cleaning-machines, the pulp is taken to the bleaching-house. After having been bleached, it is then ready to be made into paper, in the same way as other pulp. Excellent white printing paper, very good for newspapers, and at a price of three cents per pound less than is charged for the same quality of paper made from rags, is manufactured from this pulp at the Flat-rock Paper Mills, adjacent to the pulp-works. The wood-pulp must, however, be mixed with about twenty per cent. of straw-pulp, this mixture improving the quality of the paper. These works have been so successful that the price of paper for newspapers has declined three cents a pound since they have been in operation. This is a very great step in the progress of those arts which contribute so greatly to our comfort and civilization.

PROCESSES FOR PRESERVING MEAT.

In an official report laid before Parliament on the preparation of beef in South America, for the English market, three methods, proposed by Prof. Morgan of the Royal College of Surgeons in Dublin, Baron Von Liebig of Munich, and Mr. Sloper of London, are to effect this end.

Mr. Morgan's process is based on forced infiltration, using the circulatory system of the body as a means of introduction into the tissues of the animal, by injection, as detailed in the "Annual of Scientific Discovery" for 1865, pp. 52–53. The process is simple and efficacious; by it an ox can be preserved in ten minutes, using from twelve to fourteen gallons of the fluid.

Liebig's process differs essentially from the former; for the meat, instead of being preserved whole, is reduced to an essence, to be used in making soups. The concentration is carried to such an extent that thirty-three pounds of meat are reduced to one pound of essence, and the alimentary matter of an entire ox is contained in eight pounds of this preparation, making over one thousand basins of good strong soup.

It is a question of some importance whether cattle driven to the pen in a semi-wild state, which are thrown into a violent state of excitement on the approach of man, can afford nutritious meat, and can be salted without parting with by far the greater portion of such nutriment as they contain, and becoming almost valueless as food, if not altogether unwholesome.

Another attempt is being made to bring to Europe the immense supply of good meat wasted in South America. Mr. Liebert of Hamburg has attempted the manufacture of Liebig's "extractum carnis" at Fray Bentos, in Uruguay, and sends home about 4,000 pounds yearly. He is now increasing his establishments, has concluded a contract with the British Admiralty, and hopes soon to

supply the extract at sixteen shillings a pound. Each pound is the equivalent of one hundred and thirty pounds of meat, and will furnish broth for one hundred and twenty-eight men. The extract in its best state is absolutely free from fat or gelatine, and is now used very largely in continental hospitals.

The process for preparing "extractum carnis," given in Liebig's "Familiar Letters on Chemistry," is as follows: Chopped meat, deprived of all fat, is boiled for half an hour with eight or ten times its weight in water, which suffices to dissolve all the active ingredients. The decoction must, before it is evaporated, be most carefully cleansed from all fat (which would become rancid), and the evaporation must be conducted in the water-bath. The extract of meat is never hard and brittle, but soft; and it strongly attracts moisture from the atmosphere. The boiling of the meat in the first instance may be carried on in clean copper vessels; but for the evaporation of the soup, vessels of porcelain should be used. Liebig's process for making beef-tea is as follows: Raw beef (recently killed) one-half pound, distilled water twenty-two and one-half ounces, common salt fifty grains, dilute hydrochloric acid sixteen drops; macerate the beef, chopped very fine, in the water, etc., for an hour and a half; strain off through a fine hair-sieve; take two tumblers daily.

The following letter from Baron Liebig is taken from the "London Lancet": —

"SIR, — I see that rather contradictory views are expressed by different English writers on the value of the extract of meat, some taking it to be a complete and compendious substitute for meat, whilst others assert that it has no nutritive value whatever. The truth, as is usually the case, lies in the middle; and as I was the first who entered more fully into the chemistry of meat, I may be allowed shortly to state the results of my investigations, as far as the extractum carnis as a nutriment is concerned.

"Meat, as it comes from the butcher, contains two different series of compounds. The first consists of the so-called albuminous principles (*i. e.*, fibrin and albumen), and of glue-forming membranes. Of these, fibrin and albumen have a high nutritive value, although not, if taken by themselves. The second series consists of crystallizable substances, viz., creatin, creatinin, sarcin, which are exclusively to be found in meat; further of non-crystallizable organic principles and of salts (phosphate and chloride of potassium). All of these together are called the extractives of meat. To this second series of substances beef-tea owes its flavor and efficacy; the same being the case with extractum carnis, which is, in fact, nothing but solid beef-tea, — that is, beef-tea from which the water has been evaporated. Besides the substances already mentioned, meat contains, as a non-essential constituent, a varying amount of fat. Now, neither fibrin nor albumen is to be found in the extractum carnis which bears my name; and gelatine (glue) and fat are purposely excluded from it. In the preparation of the extract, the albuminous principles are left in the residue. This residue, by the separation of all soluble principles, which are taken up in the extract, loses its nutritive power, and cannot be

made an article of trade in any palatable form. Were it possible to furnish the market at a reasonable price with a preparation of meat combining in itself the albuminous together with the extractive principles, such a preparation would have to be preferred to the extractum carnis, for it would contain all the nutritive constituents of meat. But there is, I think, no prospect of this being realized. Happily, the albuminous principles wanting in the extract of meat can be replaced by identical ones derived from the vegetable kingdom, at a much lower price. Just the reverse is the case in regard to the extractive matters of meat, for (their salts excepted) it is impossible to find any substitute for them. On the other hand, they may be extracted from the meat, and brought into the market in a palatable and durable form. In conjunction with albuminous principles of vegetable origin they have the full nutritive effect of meat. From the extractive matters, then, contained in extractum carnis in a concentrated form, the latter derives its value as a nutriment for the nations of Europe, provided it can be produced in large quantities and at a cheap rate from countries where meat has no value.

"The albuminous principles of vegetable origin are principally to be found in the seeds of cereals; and the European markets are sufficiently provided with them. On the other hand, the supply of fresh meat is insufficient; and this will get worse as the population increases. For an army, for example, it will not be difficult to provide and store up the necessary amount of grain or flour. Sugar, too, as well as fatty substances and the like, will be procurable, their transport and preservation offering scarcely any difficulty. But there may easily occur a deficiency of fresh meat. Salted meat but inadequately replaces fresh meat, because, in the process of salting, a large quantity of the extractive principles of the meat is lost; besides, it is well known that those who live on salt meat for a continuance become subject to different diseases. Dried meat generally means tainted meat, scarcely eatable. Extractum carnis, combined with vegetable albumen, enables us to make up the deficiency; and that combination is the only one at our disposal. What was said of an army also holds good of those European nations in general that do not produce a sufficiency of meat. By making the most of the herds of South America and Australia, in using them for the preparation of extractum carnis, and by the importation of corn from the West of the United States and other corn-growing countries, the deficiency may be made up, although not to the full extent. For, supposing ten manufactories, producing together ten million pounds of extract of meat from a million oxen or ten millions of sheep, that whole quantity would provide the population of Great Britain only with one pound yearly for every three persons; that is, one pound a day for every eleven hundred persons.

"I have before stated that, in preparing the extract of meat, the albuminous principles remain in the residue: they are lost for the nutrition, and this certainly is a great disadvantage. It may, however, be foreseen that industrial ingenuity will take hold of this problem and solve it, perhaps by a circuitous road. For if

this residue, together with the bones of the slaughtered beasts, be applied to our fields as manure, the farmer will be enabled to produce a corresponding quantity of albuminous principles, and to better supply our towns with them, either in the shape of corn or of meat and milk. Made into a marketable state, it may hereafter replace the Peruvian guano, which very soon will disappear from the market.

"On the value of extract of meat as a medicinal substance, it is unnecessary to say a word, it being identical with beef-tea, about the usefulness and efficacy of which opinions do not differ. At the same time, I may remark that it is a mistake to think that beef-tea contains any albumen, that there ought to be any gelatine or drops of fat to swim on its surface. Beef-tea does not contain any albumen, and, if rightly prepared, ought to be free from gelatine (or glue), whilst the supernatant drops of fat form a non-essential, and, for many, an unwelcome addition.

"I should be glad if these lines could assist in clearing up public opinion on the value of extract of meat as a nutriment; my aim being, on the one hand, to reduce to their right limit hopes too sanguine; on the other, to point out the true share which the extract of meat can have in the nutrition of the people of Europe. In doing this, I know full well that whatever may be said for its recommendation would be in vain, if the extract of meat did not supply a public and generally felt necessity, and if it could not stand the test of our natural instinct, — a judge not to be bribed.

"I am, sir, your obedient servant,

"JUSTUS LIEBIG.

"*Munich, November*, 1865."

In a letter to the "London Journal of Pharmacy," written by Liebig, the following remarks occur: —

"It has been observed that the color and taste of the Fray Bentos Extract vary; this is owing to the difference of sex and age of the animals.

"The meat of oxen always yields an extract of darker color and stronger flavor, reminding somewhat of the flavor of fresh venison — pleasant when diluted. The extract of cows' meat is of lighter color, and a mild flavor, and is preferred by many persons. The meat of animals under four years cannot be used for the manufacture of extract; it yields a pappy extract of weak taste, like veal, and without flavor.

"According to the predominance of ox or cows' meat, the color and taste of extract varies, which is by no means a fault of the manufacturing process, and is fully explained by the preceding remarks. The extract of ox meat is, however, richer in creatinin and sarcin than the cows' meat extract.

"It is extremely difficult, as regards extracts of meat, — the genuineness and purity of which are not discoverable by the eye, — to protect the public against fraud. All manufacturers prepare their extract according to what they call 'Liebig's process;' but since I have given only general, and not special, directions for manufacture, it so happens that every one fills in the details after

his own fashion, and the consequence is that not one of these extracts is, in its composition, like another.

"There exist only two special directions for the manufacture of extract of meat,—the one in the "Bavarian Pharmacopœia," the other in the "Pharmacopœia Germanica"; but these directions are not mine.

"*Munich, 22d October*, 1866."

The remaining process, patented by Messrs. McCall & Sloper, professes to preserve meat in its fresh or raw state, arriving at market in the exact condition of butchers' meat just killed, but with an additional advantage of keeping twice as long as ordinary meat, after being exposed to the air.

The following is a copy of the specification taken from the English Patent Office, and published in the "Scientific American": —

"Our improvements relate to preserving fresh meat, poultry, game, and fish. We treat such food in one or other of the following methods: We immerse in or surround the meat for a short time, say from ten to fifteen minutes, more or less, with a solution of bisulphite of soda or potash, in the case or vessel in which it is to be preserved, and which must be capable of being made air-tight. By this immersion we remove the air which filled the vacant spaces in the case; we then withdraw the solution and replace it by carbonic acid gas. We repeat these immersions and supplies of gas occasionally, as required. We introduce into the case containing the food a regulated quantity of dilute sulphurous acid, and an equivalent quantity of carbonate or bicarbonate of soda, or potash, separately. The acid and alkaline salt do not come into contact until the case is hermetically closed, when they are brought into contact by agitation, and the liquid resulting, charged with carbonic acid, bathes the surface of, and impregnates the meat; or the acid and salt may be brought into contact before the case is closed; or we place the meat in a case provided with two stop-cocks, one in or near the bottom, the other in the lid. By the lower stop-cock we introduce a solution of bisulphite of soda or potash, filling the vacant spaces in the case; we then close the stop-cock in the lid, and exhaust the case of its liquid contents by powerful hydraulic suction, or by the action of an air-pump. We leave the meat under this exhausting suction, and thus draw out from the meat as much air as it will yield up, which we then expel from the case by the introduction of a solution of bisulphite of soda or potash, which we afterward withdraw and replace by carbonic acid gas. We repeat, at intervals, these alternate introductions of the alkaline solution and carbonic acid gas.

"When metallic cases are used either for preserving or packing the food, we use a lining both for the top, bottom, and sides, of a non-metallic nature, such as thin matting, wickerwork, veneers of wood, cloth, or other suitable materials.

"We preserve poultry, game, and fish, in the same manner as that described for meat.

"And having now described the nature of our said invention, and in what manner the same is to be performed, we declare that we claim as our improvements in preserving fresh meat, poultry, game, and fish, —

"First, the employment of bisulphites of soda and potash, substantially in manner hereinbefore described.

"Second, the process hereinbefore described, whatever the antiseptic salt employed.

"Third, the employment of an alkaline salt, together with carbonic acid, or the substances producing the same, sulphurous acid and carbonate or bicarbonate of soda or potash, acting in manner hereinbefore described.

"And we claim as our improvement in the vessels employed in preserving fresh meat, poultry, game, and fish, by any of the methods hereinbefore described, the lining of the same with matting, wickerwork, or other like suitable material, to protect the substance being preserved from contact with the vessels."

ON PAPER FROM CORN FIBRE.

Chevalier Von Welsbach, Director of the Imperial Printing and Paper-Making Establishments at Vienna, Austria, has brought the process of paper-making from corn fibre to great perfection. It is claimed that the paper thus made is stronger than cotton or linen paper of the same weight; that in hardness and fineness of grain it exceeds the best hand-made English drawing-paper; that it is more durable than any other paper, and is not, like parchment, subject to be destroyed by insects, thus rendering it peculiarly valuable for documents, records, etc.; that it is unsurpassed for tracing-paper, and can be made extremely transparent, and is specially adapted for photography. It is also claimed that all papers ordinarily made from cotton and linen rags can just as well be made from this material; that it can be easily converted into the finest writing and printing paper, and almost as advantageously into superior stout wrapping-paper. It readily receives any tint of color.

GELATINE FROM MARINE PLANTS.

M. Natalis Rondot made to the Society for the Encouragement of National Industry, at Paris, a communication on the subject of the marine plants from which the Chinese procure gelatine, either as an article of food or for use in the arts. The subject seems to demand attention from us, both as a means of reducing the price of a valuable article of diet, and as a means of introducing cheaper substitutes for materials of which the large consumption in the arts is raising the price seriously. The same families of plants inhabit our coast, and doubtless gelatine, as delicate in flavor, and as strong, could be easily and cheaply prepared from them.

IMPROVEMENTS IN DYEING.

New Application of Tannin. — Not only are new aniline dyes constantly discovered, but new and more convenient or effective modes of applying them are obtained. Silk and wool are easily dyed by means of them; vegetable matters, the affinities of which for colors of all kinds are much weaker, not so easily nor so effectively. It has been discovered, however, that brilliant colors may be imparted to flax or cotton by means of the aniline dyes, if they are first impregnated with an alkaline solution of tannin. Vegetable parchment, which acts like silk or wool with reference to the aniline dyes, does not require the use of tannin. When ordinary paper is to be colored, the tint obtained is wonderfully improved if it is coated with albumen before being subjected to the action of tannin.

Utilization of Aniline Dyes. — The beautiful colors derived from aniline have already received a very general application; but they have been, hitherto, unsuitable to one purpose, which would be most likely to benefit by the brilliant effects they produce, — oil painting. They are now very likely to become extremely useful in this branch of art. It has been found that a solution of aniline is capable of dissolving caoutchouc, and all the resins which have acid properties, and also the aniline dye-stuffs. The solution of shellac, for example, in aniline, may be colored by the addition of the concentrated solution of aniline dye-stuff; the result being a transparent paint, which answers admirably for glass, porcelain, etc. This shellac solution may be mixed with any oil paints that contain no lead; and thus an oil paint of extraordinary brilliancy may be obtained. With the exception of fuschine, all the aniline dyes may be dissolved in the aniline solution of shellac itself.

Aniline. — It requires as many as two thousand tons of coal to produce a small circular block of aniline twenty inches high by nine inches wide. This quantity is sufficient to dye three hundred miles of silk fabric.

Aniline Black. — The discovery of a fine black, produced from aniline, may almost be considered as completing the series of magnificent colors obtained from that substance. This new dye is the more valuable, since it may be associated with any kind of madder color, and may be treated in subsequent processes like logwood. It is obtained by dissolving hydrochlorate of aniline in an aqueous solution of hydrofluosilicic acid (spec. grav. 8° B.) which has been properly thickened, and then adding chlorate of potash, and printing or preparing the tissue with chlorate of potash, and afterward printing. On raising the temperature from 32° to 35° C., a beautiful and permanent black is produced. The hydrofluosilicic acid required may be obtained by decomposing a mixture of fluor-spar and sand with sulphuric acid. The decomposition which takes place during the process consists in decomposition of the chlorate by the hydrofluosilicic acid, silicate of potash being formed and chloric acid set free. A part of this chloric acid acts on the hydrochloric acid of the hydrochlorate of

aniline, forming a mixture consisting of free chlorine and intermediate oxygen acids of chlorine; and the remainder unites with this mixture, forming the black dye.

NITROGLYCERINE.

Nitroglycerine is the product of the reaction which ensues when glycerine is slowly poured into a mixture of concentrated nitric acid, with twice its bulk of oil of vitriol. The glycerine loses three equivalents of water, which are replaced by three of nitric acid. It has been called also trinitrine, trinitro-glycerine, etc.

It is a liquid of specific gravity 1.6, nearly insoluble in water, easily soluble in alcohol and ether. It has great stability, and keeps indefinitely; foreign bodies do not favor its decomposition; at ordinary temperatures it even remains unchanged in presence of phosphorus and potassium. It does not explode by flame; burns by contact with an ignited body, but ceases to burn as soon as the contact is at an end. It explodes only at 360° Fahr. It detonates by a violent blow of a hammer, but only the part submitted to the blow explodes, without action on the surrounding liquid. Its principal advantages in blasting in mines are, 1st. Being insoluble in water and heavier than it, it can be used in wet mines and under water. 2d. Not exploding by contact of an ignited body, unless strongly compressed, it may be carried, kept, and handled without danger. 3d. Its expansive force being ten times greater than gunpowder, it economizes labor. 4th. The rapidity of its explosion renders tamping of no importance, and thus renders the miner perfectly safe. 5th. It is as efficient in a soft and crumbling stone as in a hard and compact one; it leaves no residuum. — *Annales du Genie Civil.*

It is an oily fluid of a light yellow color, and of 1.6 specific gravity. It consists of 3 atoms of nitric-acid, or 3 NO_5, combined with an atom of glycerine, $C^6 H^5 O^3$, so that its ultimate composition may be represented by $C^6 H^5 O^{18} N$. The changes which occur during explosion convert each volume of it into 469 volumes of carbonic acid, 554 volumes of steam, 39 volumes of oxygen, and 236 volumes of nitrogen, being a total of 1,298 volumes of gas for each volume of the liquid oil, being thus five times more effective than its bulk of gunpowder; but from the greater amount of heat generated, and the consequent higher tension of the gases produced by the explosion, the new agent is really thirteen times more effective, bulk for bulk, and eight times more effective, weight for weight, than gunpowder, resulting, for blasting purposes, in very great economy of labor. — *London Mechanics' Magazine, September*, 1865.

The explosive properties of nitroglycerine $C^6 H^5 (N\ O)_1 O^6$, and the accounts of experiments made with it in different parts of Sweden, Germany, and Switzerland, determined MM. Schmitt and Dietsch, the proprietors of the great quarries of sandstone in the valley of Zorn, Lower Rhine, to try to use it in their works.

The trial proved so successful, both as regards economy and the ease and rapidity with which the work was performed, that,

for the time, at least, they have abandoned the use of powder, and the quarries have been entirely worked by nitroglycerine for six weeks.

From the first, we have considered that the nitroglycerine should be prepared on the spot. It always seemed to us the transportation of an explosive compound of such frightful power ought not to be allowed either by land or water. The terrible accidents which have happened at Aspinwall and at San Francisco justify these fears; and the transportation of nitroglycerine should be positively forbidden.

After having, with M. Keller's assistance, studied in my laboratory the different processes of the preparation of nitroglycerine (mixtures of glycerine with concentrated sulphuric acid and nitrates of potash and soda, or with nitric acids of different concentrations), we have determined on the following method of manufacture, which is performed in a wood cabin, constructed in one of the quarries: —

Preparation of Nitroglycerine. — We begin by mixing in an earthenware vessel placed in cold water some fuming nitric acid at 49° or 50° Baumé (1.51 — 1.53) with twice its weight of the strongest sulphuric acid. These acids are purposely prepared at Dieuze, and sent on to Saverne. At the same time, we evaporate in a pot some commercial glycerine free from both lime and lead, until it makes 30° or 31° Baumé (1.26 — 1.27). This concentrated glycerine should, after cooling, have a syrupy consistence.

The workman then throws thirty-three hundred grammes of a mixture of sulphuric and nitric acids, well cooled, into a glass flask (a pot of earthenware or a capsule of porcelain might equally be employed) placed in a trough of cold water, and then he slowly pours into it, stirring it continually, five hundred grammes of glycerine. The thing to be observed is the avoidance of any sensible heating of the mixture, which would determine a tumultuous oxidization of the glycerine, and the production of oxalic acid. For this reason it is, that the vessel in which the transformation of the glycerine into nitroglycerine takes place should be constantly cooled externally by cold water.

When the materials are thoroughly mixed, the whole must be left for five or ten minutes; then pour the mixture into five or six times its volume of cold water, to which a rotatory movement must first be imparted. The nitroglycerine precipitates very rapidly, under the form of a heavy oil, which is collected by decantation into a vessel; then wash it with a little water, which is in its turn decanted; pour the nitroglycerine into bottles, and it is ready for use.

In this state, the nitroglycerine is still slightly acid and watery; but this is of no importance, since, as it is employed soon after its preparation, these impurities in no degree prevent detonation.

Properties of Nitroglycerine. — Nitroglycerine is a yellow or brownish oil, heavier than water and insoluble in it, but soluble in ether, alcohol, etc.

Exposed to a prolonged but not intense amount of coldness, it crystallizes in long needles. A violent shock best causes it to

detonate. The handling of it is now easy, and only slightly dangerous. Spread upon the ground, it is only with difficulty fired by a body in combustion, and then only burns partially; a flask containing nitroglycerine may be broken upon stones without its detonating; it may be volatilized without decomposition by a regulated heat; but if it boils, detonation becomes imminent.

A drop of nitroglycerine falling on a metal place moderately heated volatilizes quietly. If the plate be red-hot, the drop is immediately fired and burns like a grain of powder, only noiselessly; but if the plate, without being red-hot, is hot enough to make the drop boil immediately, it decomposes suddenly with a violent detonation.

Nitroglycerine, especially when impure and acid, decomposes spontaneously after a certain time, with an escape of gas and the production of oxalic and glyceric acid.

Probably the spontaneous explosions of nitroglycerine, with whose disastrous effects the papers have acquainted us, are owing to the same cause. The nitroglycerine being inclosed in well-corked bottles, the gases produced by its spontaneous combustion cannot escape; they then excercise an immense pressure on the nitroglycerine, and in this state the least shock and the slightest movement will cause an explosion.

The flavor of nitroglycerine is at once sweet, piquant, and aromatic; it is poisonous, and taken in small doses it produces bad headaches. Its vapor produces similar effects, and this reason might well prove an objection to its use in the subterranean galleries of mines, where its vapors cannot disperse as they do in open-air quarries.

Nitroglycerine is not, properly speaking, a nitrated body, such as nitro- or binitro-benzol, or mono-, bi-, and trinitro-phenisic acids. Indeed, under the influence of reducing bodies, such as nascent hydrogen, sulphuretted hydrogen, etc., the glycerine is set at liberty, and the caustic alkalies decompose the nitroglycerine into nitrates and glycerine.

Modes of Employing Nitroglycerine.—Suppose the object is to detach a stratum of rocks. At 2.50 to 3 metres distance from the exterior border, sink a mining hole about 5 or 6 centimetres in diameter, and 2 or 3 metres in depth.

After having thoroughly cleared all mud, water, and sand out of the hole, pour into it, through a funnel, from 1,500 to 2,000 grammes of nitroglycerine. Then immerse in it a little cylinder of wood, pasteboard, or tin, about 4 centimetres in diameter, and from 5 to 6 centimetres in height, and filled with ordinary powder. This cylinder is fixed to an ordinary mining fuse, which goes down a certain depth to insure the combustion of the powder. The cylinder is lowered by means of the wick or fuse; the moment the cylinder reaches the surface of the nitroglycerine may easily be known by the touch. When it touches the surface, hold it perfectly still, and pour sand into the hole until it is quite full; there is no need to compress or plug the sand. Cut the wick some centimetres from the orifice of the hole, and then set fire to it. In about eight or ten minutes,

the match burns down to the powder and fires it. Then ensues a violent shock, which immediately causes the detonation of the nitroglycerine. The explosion is so sudden that the sand is not even projected.

The whole mass of the rock rises, is displaced, then re-settles without any projection; only a dull detonation is heard.

Only on examining the spot can an idea be formed of the power of the force developed by the explosion. Formidable masses of rock are slightly displaced and rent in every direction, and ready to be removed mechanically.

The chief advantage is that the stone is only slightly crushed, and there is very little waste.

In the manner we have shown, from forty to eighty cubic metres of rock may be detached by charges of nitroglycerine.

We trust to have shown by this notice the possibility of reconciling the employment of nitroglycerine with every desirable guarantee for public safety. — M. Kopp, *Comptes Rendus.*

The following are extracts from a letter by T. P. Shaffner, in the "Scientific American," for Nov., 1866: —

"When I visited the Hoosac Tunnel in August, I had not witnessed the explosion of nitroglycerine in rock of the hardness of the Hoosac Mountain. The tunnel is penetrating through solid massed mica and quartz. The strata lie against the progress, and there are but few seams and slips. It tears roughly, and in no instance quarries. Every cubic inch must be blasted.

"The 'heading' is 6 feet high and 15 feet wide. Below is the 'bench,' or bottom enlargement, 4½ feet deep, the width of the heading. In the west shaft it was about 300 feet in the rear of the heading. The further enlargements are to be above and at the sides. My experiments were in the west shaft, 'bench' and 'heading,' proceeding eastward.

"Prior to my arrival, good miners had been making from 2 to 3 feet per day with the 'bench.' The holes had been set from 15 to 20 inches back, drilling 4 holes to make the width of the tunnel. These 4 holes were drilled 4 feet deep, charged with powder and well tamped. After blasting the 4 holes, about 5 short holes, averaging 15 inches, had to be drilled in order to make an even bottom. According to these figures, the number of inches to be drilled to make 60 7-10 feet lineal, would be 9,612. Two men can drill about 100 inches per day of 8 hours, and wages are $2.25 per day. The expense for miners, tools, and incidentals, amounts to about $6 per 8 hours, for each 100 inches, making a total of $566.72 for drilling. The time required to make 60 7-10 feet would be at least 20 days. There would be about 144 long holes, 180 short holes, and at least 36 blasts. This is the rate of progress that had been made with gunpowder.

"My first experiment was in the 'bench,' as above described, and within 3 days I advanced 60 7-10 feet. I used nitroglycerine, exploded by the aid of electricity. If the rock could be removed after each blast, I can make 70 feet in that time. I had 9 blasts and 28 holes, 5 feet deep; total inches drilled, 1,680. The cost of the nitroglycerine was less than the price of gunpowder for the same number of feet.

"My next experiment was in the 'heading,' for a period of 3 days. The average speed per month with powder had been 64 feet, blasting every 2 hours holes 20 to 30 inches deep. When I commenced my experiment, the rock was excessively hard, and the trial was very severe against me. I blasted 15 holes every 8 hours; holes 30 to 36 inches deep. Within the 3 days I made 14½ feet. The next 3 days the rock happened to be better for blasting, and powder was used, making 6 4-10 feet. Number of nitroglycerine holes 132, and about 4,356 inches for the 14½ feet. Number of powder holes 180, and about 4,500 inches drilling, making 6 4-10 feet.

"In the same class of rock, I am of opinion that I can make at least 35 feet per week in the heading, and in a month of 27 days about 158 feet; making 94 feet per month more than can be accomplished with gunpowder.

"From these figures, the Hoosac Tunnel can be finished in less than half the time and for less than half the expense by using nitroglycerine. From 8 to 10 years has been the estimated time for completing the work, and the expense several millions of dollars. From these economic considerations, the very able chief engineer of that great enterprise is encouraged to belief in the early completion of the work by his adopting nitroglycerine."

Though this substance possesses very important advantages over gunpowder, as a blasting and destructive agent, the attempts to introduce it as a substitute have been attended by most disastrous results, ascribable, in part, to some of its properties, and too evident instability of the commercial product, but principally to the thoughtlessness of those interested in its application, who appear to have been induced, either by undue confidence in its permanence and comparative safety, or from less excusable motives, to leave the masters of ships, or others who had to deal with the transport of the material, in ignorance of its dangerous character.

The precise cause of the fearful explosions of nitroglycerine at Aspinwall and San Francisco will probably never be ascertained; but they are likely to have been due, at any rate, indirectly, to the spontaneous decomposition of the substance, induced or accelerated by the elevated temperature of the atmosphere in those parts of the ship where it was stored. Instances are on record in which the violent rupture of closed vessels containing commercial nitroglycerine has been occasioned by the accumulation of gases generated by its gradual decomposition; and it is not improbable that a similar result, favored by the warmth of the atmosphere, and eventually determined by some accidental agitation of the contents of the package, was the cause of those lamentable accidents. The great difficulties attending the purification of nitroglycerine upon a practical scale, and the uncertainty, as regards stability, of the material, even when purified (leaving out of consideration its very poisonous character, and its extreme sensitiveness to explosion by percussion, when in the solid form), appear to present insurmountable obstacles to its safe

application as a substitute for gunpowder. — *Journal of Franklin Institute, Oct.*, 1866.

GUN-COTTON.

M. Blondeau makes the following communication to the Academy of Sciences, Paris. If gun-cotton of good quality be exposed for about four hours to the action of the vapor of ammonia, it will soon assume a yellow tint, indicating its combination with the ammonia; and, after being dried, it furnishes a powder which is unalterable at ordinary temperatures, and even undecomposable at 212° (Fahr.), and possesses an explosive force greater than that of ordinary gun-cotton.

Gun-cotton has not hitherto been received with much favor by artillerists, but some recent experiments of Mr. Whitworth go far to prove that, under certain circumstances, it may be used with advantage. He finds that a charge made up of gunpowder and gun-cotton, the former material being exploded first, gives a lower trajectory, and will also admit of a lighter gun being used. By this means, the great explosive power of gun-cotton is combined with the advantages due to the gradual action of ordinary powder.

GUN-PAPER.

Mr. G. S. Melland, of Lime street, London, who has distinguished himself among British makers of fire-arms, has recently invented a "gun-paper," to supersede the old gunpowder. The invention consists in impregnating paper with a composition formed of chlorate of potash, 9 parts; nitrate of potash, 4½; prussiate of potash, 3¼; powdered charcoal, 3¼; starch, 1-12th part; chromate of potash, 1-16th part; and water 79 parts. These are mixed, and boiled during one hour. The solution is then ready for use, and the paper passed in sheets through the solution. The saturated paper is now ready for manufacturing into the form of a cartridge, and is rolled into compact lengths of any required diameter. These rolls may also be made of required lengths, and cut up afterward to suit the charge. After rolling, the gun-paper is dried at 212° Fahr., and has the appearance of a compact grayish mass. Experiments have been made with it, and it has been reported favorably of as a perfect substitute for gunpowder, superseding gun-cotton and all other explosives. It is said to be safe, alike in manufacture and in use. The paper is dried at a very low temperature. It may be freely handled without fear of explosion, which is not produced even by percussion. It is, in fact, only exploded by contact with fire, or at equivalent temperatures. In its action it is quick and powerful, having, in this respect, a decided advantage over gunpowder. Its use is unaccompanied by the greasy residuum always observable in gun-barrels that have been fired with gunpowder. Its explosion produces less smoke than from gunpowder; it is said to give less recoil, and it is less liable to deterioration from dampness. It is readily protected from all chance of damp by a solution of xyloidin in nitric acid.

In experimenting with this new explosive substance, six rounds were first fired with cartridges containing 15 grains of gunpowder, and a conical bullet, at 15 yards range, which gave an average penetration of 1 1-16 into deal. Six rounds were then fired with 10 grains of gun-paper and a conical bullet, at the same range, and gave an average penetration of 1 3-8 into deal. Here was 33 per cent. less of paper than powder, and greater penetration with paper. Six rounds followed with an increased charge of 15 grains of gun-paper and a conical bullet, at the same range, and at each shot the bullet passed through a 3-inch deal. At 19 yards range, 12 grains of the paper, fired from a pistol of 54 gauge (44-inch), sent a heavier bullet through a 3-inch deal. A fouled revolver was preserved four days, but betrayed no symptoms of corrosion after using gun-paper. It is expected that gun-paper will be manufactured cheaper than gunpowder.—*London Artisan.*

NEW GUNPOWDERS.

Some interesting experiments were made in Paris recently with a new kind of gunpowder, the invention of M. Neumann. This composition appears to be very similar to that of ordinary powder, but it has the property of not exploding unless subjected to pressure. When laid upon the ground and ignited, the new gunpowder burns slowly and leaves a thick crust. In the course of the experiment, three barrels, each containing about three and a half kilos. of powder, were placed in a temporary hut, and the powder was ignited by means of a fusee. Large volumes of smoke were seen to issue from the crevices, but no explosion took place, the powder being simply burned. When tried in a rifle, the strength, when the ramrod was well used, was found to be equal to that of ordinary gunpowder; but, when not rammed, it failed even to drive the ball out of the muzzle. The composition of the powder remains a secret for the present.

At a recent meeting of the British Association, a paper was read upon the introduction of a new gunpowder for heavy ordnance, in which nitrate of barytes is substituted for saltpetre in composition; the consequence being that the powder, when ignited, consumes more slowly, and the gases are developed less rapidly, while the same effect is produced upon the projectile as regards its ultimate velocity.

NEW GUNPOWDER.

A new and very powerful gunpowder has been patented by Captain Schultze, of the Prussian Artillery, which possesses some very valuable advantages. In composition and mode of manufacture it bears more resemblance to gun-cotton that to ordinary gunpowder; but its form is that of gunpowder, and it has none of the specially dangerous properties which have hitherto prevented gun-cotton from coming extensively into practical use. Cotton fibre consists of "cellulose," a compound of six atoms of carbon, five of oxygen, and ten of hydrogen; while gunpowder is, chemically

speaking, "tri-nitro-cellulose," or cellulose which has had three atoms of its hydrogen replaced by hyponitric acid. All kinds of wood consist chiefly of cellulose; the cellulose of wood, however, is unlike that of cotton fibre, which is quite pure, being always combined with more or less coloring matter, resin, and various earthy and other substances. It is obvious, therefore, that if we could remove from wood all the substances other than cellulose which enter into its composition, and were to subject the pure cellulose then remaining to the same chemical treatment that cotton fibre has to undergo in order to be converted into gun-cotton, we should obtain a substance of absolutely the same composition as gun-cotton, and differing from it only in form. This is just what Capt. Schultze does, with the result that he gets "tri-nitro-cellulose," not in delicate filaments like gun-cotton, exploding almost instantaneously, but in hard, compact grains, of any desired size, and at least as slow of combustion as the densest gunpowder of the same size of grain. While gun-cotton, being, at least for gunnery purposes, only three times as powerful as its weight of gunpowder, costs, weight for weight, six times as much as gunpowder costs, and can only be used safely by means of special methods, this new product, while nearly four times as powerful as gunpowder, costs, weight for weight, considerably less than gunpowder, and can be used in precisely the same way, the only precaution necessary being to use of the new powder only one-fourth as much as of the old.

Any hard wood is cut into sheets about one-sixteenth of an inch thick, and punched into little cylinders, which constitute eventually the grains of the powder, which is thus granulated at the beginning instead of at the end of the process of manufacture. To remove all constituents except cellulose, these granular cylinders are boiled for about eight hours in strong solutions of carbonate of soda, frequently changed; after twenty-four hours washing in running water, they are next steeped for two or three hours in a chlorinated solution; after a second twenty-four hours' washing in cold running water, they are submitted for six hours to the action of a mixture of forty parts, by weight, of concentrated nitric acid with a hundred parts, by weight, of concentrated sulphuric acid, one part of the grains, by weight, being placed with seventeen parts by weight of the mixed acids in an iron vessel, which should be kept cool. The grains then being carefully drained, they are exposed to cool running water for two or three days, then boiled in a weak solution of carbonate of soda, again exposed for twenty-four hours to running water, and carefully dried. Up to this point the grains are not explosive. The dried grains are now steeped for ten minutes in a solution of some salt or salts containing oxygen and nitrogen — the best appears to be for every hundred parts by weight of the grains, two hundred and twenty parts of water, having dissolved in it twenty-seven and one-half parts of nitrate of potash and seven and one-half parts of nitrate of barytes, at a temperature of 112° Fahr. After draining, they are dried in a chamber at 90° to 112° Fahr. for about eighteen hours.

This new powder will be of use not only for small arms and artillery, but for mining and engineering purposes; its great

advantage in the latter is that its explosion produces no smoke, thereby avoiding the loss of time incurred by the workmen under ground in waiting for the smoke of common gunpowder to clear away; it has all the advantages of gun-cotton, without its danger and other disadvantages. —*London Mechanics' Mag., March*, 1865.

THE PRUSSIAN NEEDLE-GUN.

The deciding argument of the recent European battles has been the *Zund Nadel-Gewehr*, —the Prussian needle-rifle. The wonders which the Austrian army have usually performed with the bayonet were completely estopped by this terrible weapon, as, loading and firing it from five to seven times a minute, the Prussian soldiery spent such a shower of bullets upon the advancing foe, that, by the time they reached them, there were not enough left living to do much harm. No men, however brave and determined, could stand the fire of these rifles; and nothing so disheartens an army as the absolute knowledge that it is fighting against a terrible superiority in arms.

The "needle-rifle," which has been in use in the Prussian army since 1848, but which has never till now been fairly tested, has proved to be a most formidable and dangerous weapon; and as the Prussians have succeeded in this war, they may in great part consider it due to their superiority in the possession of this fearful instrument of warfare. It is a breech-loading rifle, the cartridge used being made of stiff card-board, the ball, powder, and explosive composition being contained in one and the same cylinder. Its great peculiarity is, that the detonating powder is placed immediately in rear of the base of the ball, and between it and the powder. The advantage of this is, that when the powder is ignited, that portion next the ball, in which combustion is first perfected, exerts its full force upon the projectile, the powder in rear also exerting its influence, as it becomes almost simultaneously ignited. Under the present system, in which that part of the powder next to the breech of the gun is first ignited, a portion of the powder is frequently expelled from the gun with the ball, in a condition of only partial combustion, the explosive force of the powder first consumed being adequate to expel the ball and the powder in its front, before the whole charge has time to become entirely ignited. Thus, in the needle-gun, all the powder is consumed and applied to the best effect, and so as to obtain its fullest force at the same instant and in the same direction.

The needle-gun is a breech-loader, and, when the trigger is pulled, a stout needle or wire is thrust through the base of the cartridge, parallel with its axis, into the detonating charge by the ball, causing its explosion and the ignition of the cartridge. In accuracy the needle-gun cannot be surpassed; and its effective range is said to be about fifteen hundred yards. Soldiers can load and fire five times a minute; and, in the recent fighting, they have been in the habit, when either charging themselves or receiving charges, to keep the gun at the hip, and simply continue putting in cartridges and discharging them, literally keeping up

what my informant describes as a "rain of bullets." This mode of firing accounts for the fact of so many of the Austrians being wounded in the legs and feet. — *Druggists' Circular*, 1866.

So much has been said about the Prussian needle-gun of late, in the foreign journals, and the success of the Prussians with it, that many suppose it to be a new invention. On the contrary, it is twenty years old. We do not desire to depreciate it on this ground, but, judging it solely by its intrinsic merit, it is not up to the standard of American breech-loaders. All military men know that an essential point in a fire-arm is simplicity and certainty in fire. Neither of these qualities is found in the needle-gun, for the mechanism is clumsy, compared with recent inventions, and the ammunition is complicated, and costly to prepare. The principal idea in this weapon is in firing the charge from the front instead of behind, as in other weapons. To do this, the percussion powder is put into a cavity in the base of a paper sabot, between the ball and the powder, the charge being exploded by a wire or needle thrust through the cartridge.

The experience gained in the war of the rebellion shows us that the "magazine arm," or that weapon where the charges are contained in the breech, is most deadly, when in the hands of skilful troops. Other breech-loaders have their good qualities, but all who remember the part the Spencer rifle bore in the contest will concede the point we make.

Breech-loaders have this disadvantage: troops must be trained long and thoroughly, or in the heat of battle the charges will be thrown away from heedless firing. The Prussian army have had experience with breech-loading guns for fifteen years, and in their recent battles did well. — *Scientific American*, 1866.

IMPROVEMENTS IN CANNON.

At the anniversary meeting of the American Academy of Arts and Sciences, Boston, Mass., in May, 1865, the Rumford medal was awarded to Prof. Daniel Treadwell, of Cambridge, Mass., "for improvements in the management of heat made and put in practice by him in constructing cannon of a series of coiled rings, in the year 1842."

The following are extracts from the address of Prof. Asa Gray, the President, on the occasion of its presentation, in Nov., 1865: —

"We in our day, within the last fifteen years, have witnessed a change in the means of attack and defence greater than any made in the two hundred years previous, — a change involving a complete revolution in tactics, both on land and on sea. To take a single illustration from heavy ordnance, in which the importance of the change impresses us, when we are told that our strongest forts, armed with the best guns we had ten years ago, could oppose no effectual resistance to the entrance of such ships as are now built, into any of our harbors; and that a ship could now be built and armed, which, singly, would overmatch our whole navy as it was in 1855.

"Fortunately, the balance is redressed by equal improvement in defence.

"The improvement in fire-arms, both great and small, is in their increased range and precision. When the effective range of a musket-ball was extended from two hundred yards to fourteen hundred or more, it became imperatively necessary that ordnance should be improved in the same ratio, or it would be useless, as gunners and horses would be picked off by small arms long before they could effectively reach the enemy. This improvement in guns of great calibre has been made, with consequences the importance of which, present and prospective, cannot be over-estimated.

"But the point which we have to consider is, that this increased range and precision are entirely dependent on the augmented strength of the gun. The weakness of the gun is the only thing that imposes a limit to the range short of the absolute strength of the explosive material used. It is the strength of the gun which not only gives the range, but makes rifling possible, with precision and all the advantages of the elongated shot. All inventions relating to the different modes of rifling, the form of the projectile, and the devices for breech-loading, are necessarily subordinate to the question of strength: with this sufficient, those become simple problems, to be rapidly determined by the ingenuity of many inventors.

"Now the limit of strength of cast-iron and of bronze cannon had long ago been reached. Excepting Captain Rodman's improvement, and certain modern advantages in working and casting metals, no material advantages had been gained over guns cast in the reign of Queen Elizabeth.

"But the most effective guns of the present day embody new principles of strength. They are all built-up guns. With them are associated the names of Armstrong, Blakely, Whitworth, Parrott, and others. Whatever may be the relative merits of these several varieties, our interest is confined to the question of their strength, that is, to the principles of construction which have made them stronger than common guns, and rendered their respective subordinate improvements possible.

"These principles are two, and their introduction at different times into the manufacture of cannon constitute two successive steps, and the only steps, which give distinctive character to the guns under consideration. Both originated with Mr. Treadwell.

"These two inventions are often confounded, although more than ten years elapsed between them. The confusion is doubtless owing in some degree to the fact that the two are found combined in nearly all the modern built-up guns. The first initiated a system of construction which may be designated as the coil system; the second, what may be named the hoop system.

"The first was successfully applied to the making of cannon by Mr. Treadwell in the year 1842, and a full account of it was published in 1845; the gist of the invention being in so constructing the gun that the fibres of the material shall be directed around the axis of the calibre.

"This method of construction is described in Professor Treadwell's own language as follows: 'Between the years 1841 and

1845 I made upwards of twenty cannon of this material (wrought-iron). They were all made up of rings, or short hollow cylinders, welded together endwise; each ring was made of bars wound upon an arbor spirally, like winding a ribbon upon a block, and, being welded and shaped in dies, were joined endwise when in the furnace at a welding heat, and afterwards pressed together in a mould by a hydrostatic press of one thousand tons' force.

"'Finding in the early stage of the manufacture that the softness of the wrought-iron was a serious defect, I formed those made afterwards with a lining of steel, the wrought-iron bars being wound upon a previously formed steel ring. Eight of these guns were six-pounders, of the common United States bronze pattern, and eleven were thirty-two-pounders, of about eighty inches' length of bore, and one thousand nine hundred pounds' weight.'

"The soundness and value of this principle of construction were fully confirmed in England by the experiments of Sir William Armstrong in 1855, and attested by his evidence before a committee of the House of Commons in 1863. He there describes his own gun as one 'with a steel tube surrounded with coiled cylinders,'—as 'peculiar in being mainly composed of tubes, or pipes, or cylinders, formed by coiling spirally long bars of iron into tubes and welding them on the edges, as is done in gun-barrels.' His indirect testimony to the originality of Mr. Treadwell's process is equally clear, being that, within his knowledge, no cannon had ever been made upon this principle until he made his own in 1855, he being, as we must suppose, ignorant of what Mr. Treadwell had done thirteen years before. The statement of Mr. Anderson (witness before the Commons' Select Committee), made before the Institute of Civil Engineers in 1860, is equally explicit as to the nature and value of this method of constructing cannon. And, finally, the high estimate of its importance abroad is shown not only by the honors and emoluments conferred by the British government on the re-inventor, but still more by the actual adoption of this gun as the most efficient arm yet produced. For it must be borne in mind that the faults or failures, complete or partial, of the Armstrong and similar guns, are not of the cannon itself, as originally constructed, but of breech-loading contrivances, of the lead coating of the projectile, or of other subsidiary matters.

"That our colleague's invention, the value of which is now so clearly established, should have been so generally unacknowledged by inventors abroad is his misfortune, not his fault. For, not only were his guns made and tested here, and their strength as clearly demonstrated before 1845 as they have been since, not only was a full account of the process and of the results published here in that year, but a French translation of his pamphlet was published in Paris, in 1848, by a professor in the school of artillery at Vincennes; and Mr. Treadwell's patent, with full specifications, was published in England before Sir William Armstrong began his experiments.

"The difficulties to be overcome in making such a gun,—great

at all times, as Sir William Armstrong and Mr. Anderson testify, — were far greater in 1842 than in 1863. These difficulties were mainly, if not wholly, in welding large masses of wrought-iron in the shape of tubes or cylinders. It is for overcoming these difficulties that this medal is bestowed, and especially for the means and appliances by which this difficult mechanical achievement was effected in the furnace 'by the agency of fire.'

"An incidental but noteworthy part of the improvement was the welding by hydrostatic pressure, — an operation which is just now coming into use in England, but has not yet attracted attention in this country.

"We come now to the second improvement in the construction of artillery, the invention of the hooped gun.

"This is not always clearly distinguished, even by those occupied with the subject, from the gun formed of coiled rings. But a simple statement will bring into view distinctly the new principle of strength here introduced.

"If an elastic hollow cylinder be subjected to internal fluid pressure, the successive cylindrical layers of the material composing it, counting from within outwards, will be unequally distended, and the resisting efficiency of the outer layer will be less than that of any layer nearer the axis. And if the walls of the cylinder are thick, and the internal pressure surpasses the tensile strength of the material, its inner layer will break before the outer one has been notably strained. Hence the tensile strength of a square inch-bar of the material is the measure of the maximum pressure the cylinder can bear, when constructed as guns were before the introduction of the improvement now under consideration. The improvement does away with this limit, and enables us to go indefinitely beyond it.

"This is accomplished by so constructing the gun that the inner layers are compressed by the outer; whereby the internal pressure is first resisted by the outer layers, which must be distended enough to allow the internal compressed portion to attain its normal conditon before this internal portion (which is the first to break in the common gun) is subject to any strain at all. It will be perceived, that, if this principle could be rigorously applied, a cannon could be made so perfect, that, when subjected to a bursting pressure, every fibre, from the internal to the external surface, would be at that instant equally extended, each contributing its full share of resistance to fracture. The whole resistance would be proportional to the area of fracture.

"This was supposed to be the case in common cylinders before the error was pointed out by Barlow, and also by Lamie and Clapeyron. And it was this erroneous supposition that led Count Rumford to his exaggerated estimate of the force of gunpowder, as tested by its power of bursting gun-barrels. If he had used the theory which gave origin to the hooped gun, his results would nearly have agreed with modern observations.

"The demonstration of the superiority of the hooped gun, with detailed directions for its construction, is contained in a paper read before this Academy in February, 1856, and published at the

beginning of the sixth volume of our 'Memoirs.' This was the first published account of the invention, which had been patented nearly a year before. Captain Blakely's pamphlet, published in England in 1858, sets forth the advantages of this construction by similar arguments; as also does an elaborate paper read by Mr. Longridge before the Institution of Civil Engineers in February, 1860. Both these gentlemen, however, were engaged in researches upon this subject at an earlier date, but not so early, it would appear, as was Mr. Treadwell.

"The validity of the principle, and the soundness of Mr. Treadwell's views upon the whole subject, as set forth in his memoir, have been amply confirmed by special experiments made in England with the Blakely and Whitworth guns, and by experience in this country, during the last four years, with the Parrott and the Blakely guns.

"It must not be supposed that the earlier invention is superseded by the later one. That is used in forming the hoops of the Parrott gun, and in most of the British guns. And the best gun which could now be made, as experience has shown, would be composed of a barrel of cast-iron or steel, inclosed and compressed by a cylinder of coil.

"We need not discuss the question of priority of invention between Mr. Treadwell and others, competitors for a share in the honor of producing the modern cannon. His independence of each and all of them has never been called in question. Nor will it ever seriously be thought that the previous futile attempts at constructing wrought-iron and banded guns — foredoomed failures both in theory and practice, and destitue of all pretension to a knowledge of the guiding principles now clearly seen to be essential to success — should detract in the slightest degree from the great honor which our associate has, by a clear insight into the conditions of the problem and the resources of physical science, so fairly and completely won.

"Upon these two inventions has been set the seal of experience. But there is another memoir, read by Professor Treadwell before this Academy in April, 1864, and printed soon afterwards, which promises to add a third important improvement in the construction of artillery.

"Perceiving that the body of a hooped gun, if made of unmalleable cast-iron, compressed by a soft wrought-iron hoop, must give way, by the fracture of the cast-iron hoop, before the hoop can approach the ultimate limit of its strength, and that this was, in fact, a principal cause of the failure of so great a part of the large guns of Blakely and Parrott, Professor Treadwell, as the principal result of this third investigation, proceeds to show, that, to attain with effect the end sought for by hooping a cast-iron gun, it is necessary to harden the wrought-iron hoop by cold hammering and severe stretching before placing it upon the gun-body. He computes that, by this simple means, a hooped gun may be made more than twice as strong as those which have been constructed by Blakely and Parrott, the materials being in both cases the same.

"In this important discovery, as also in other matters discussed in his latest memoir, we are gratified to see, that, although now carrying the weight of more than three-score-and-ten years, our veteran colleague still keeps the lead, which he gained at the start, of his competitors in this race of improvement.

"So completely do these three improvements cover the ground, that, if the works of all other inventors who claim a share in the great gun of the nineteenth century were lost, the gun could be restored (rifling excepted) from Mr. Treadwell's papers alone."

CASTING OF A TWENTY-INCH CANNON.

Another twenty-inch gun was recently cast at the Fort Pitt Iron Works, Pittsburg, Pa., being the third one of that size. This is the first naval gun, however, and is intended for the "Puritan," consort of the "Dictator," both ocean monitors. The two previously cast were army guns. They are Rodman guns, that is, cast with a water-cooled core.

The quantity of metal melted at once was enormous; not less than 140,000 pounds, and three furnaces were in use to accomplish it in time, the fires being started at 4.30 A. M. on the morning of pouring. The iron was in the following proportion: 101,000 Juniata, second fusion; 39,000 Juniata pig, from the Bloomfield furnace: this is stated to be the finest quality of metal, for gun founding, in the country. The furnaces were tapped at 12.10, and the mould was filled in a short time.

The length of the rough casting is 236 inches. The maximum diameter is 65½ inches, and the minimum 48 inches. When finished, the breech of the gun will measure 64 inches in diameter, and the nozzle 35½ inches. The length of the cylinder bore is 147 inches, depth of chamber 10 inches. The thickness of metal outside the bore, at the breech, is 22 inches, and at the nozzle 7 9-10 inches. Diameter of trunnion 18 inches. At 9.20, Sunday morning, the water was turned off, at which the temperature was 97°. The core barrel was hoisted, when it came out perfectly clean, there being every indication of perfect success in the casting. After the barrel was hoisted out, a very small stream of water was allowed to flow into the bore, when it immediately became steam. This was to be continued until 8 o'clock, when a column of cold air would be forced in, and the cooling process completed in this way. — *Scientific American.*

THE PALLISER GUN.

Last August, four Palliser guns were tested with perfect success at the proof butt in the Royal Arsenal at Woolwich, under the superintendence of Lieutenant-Colonel Freeth, Assistant Superintendent of the Royal Gun Factories. These guns were formerly cast-iron 32-pounders and 24-pounders, and have been converted into 64-pounders and 56-pounders, at Elswick. Twenty more of these guns arrived the same day at Woolwich, and will at once be sent to proof. A 64-pounder Palliser gun has also undergone

a most severe test of endurance. This was a 32-pounder, weighing only 58 cwt. According to the "Times," the test was as follows: Two rounds, with charges of 16 lbs. of powder and 150 lb. cylinders; 10 rounds, with charges of 20 lbs. of powder and 100 lb. cylinders; and, finally, 10 rounds, with 16 lbs. of powder and 64 lb. shells. The shells were loaded with their fuse-holes toward the powder, and, as the fuses had been taken out, the flash of the discharge set fire to the powder in the shells and burst them in the gun. It was generally expected that this test would have burst the gun, or, at all events, that it would have blown off the muzzle, or otherwise have rendered it unserviceable; but beyond the one fact of the bore being scratched by the splinter of the shells, no injury was perceptible, and the gun was loaded with the same facility and fired as before. It appeared from a subsequent examination that some of the shells had burst before they had moved, and that others had burst close to the muzzle of the gun. A number of 64-lb. shot were then fired with 16-lb. charges, but, instead of the shot being rammed home, they were only pushed down to certain positions in the gun, so as to leave vacant spaces of 5 inches, 10 inches, 15 inches, 20 inches, and 25 inches between the powder and the shot. To the astonishment of every one present, the gun had not sustained the slightest injury. It was therefore decided by the Ordnance Select Committee to put the gun through a supplementary trial to ascertain its maximum or highest power of endurance, when it will have to fire 20-lb. to 25-lb. and 30-lb. charges, with cylinders of 150 lbs. weight. Major Palliser has expressed great confidence in the strength of the gun, and states that he has no fear of the result of any reasonable amount of proof, even beyond what is absolutely necessary. The trial, it is admitted, has already borne out the anticipations of the inventor and manufacturers, and has fully justified the recommendation of the Ordnance Select Committee, and their introduction of these guns for the consideration of the War Department to use up the heavy stock of guns on hand. On account of their weight, their service charges will be only 6 lbs. or 8 lbs. of powder. Sufficient evidence, it is stated, has already been obtained to prove that we have thus a most efficient and reliable addition to our stock of rifled ordnance; a fact which, in the present difficulties with which the government is embarrassed for want of serviceable guns, will be hailed with much satisfaction, more especially as the two new guns now pronounced successful, — those of Major Palliser and Mr. Frazer, — will be produced at a cost far below that of the present guns, in which the country have long since ceased to have any confidence. — *Mechanics' Magazine.*

CHILLED SHOT.

Mr. Fairbairn, in his treatise on iron ship-building, which appeared so recently as the close of last year, records his opinion that cast and wrought iron were not materials calculated to make a serious impression upon armor-plates, and that nothing had been found to answer the purpose better than hardened steel. The

cast-iron prepared by Dr. Price, and the case-hardened shot prepared by Major Palliser, Mr. Fairbairn considered, might answer the purpose in some cases; but he questioned whether this material, however well prepared, could be made to hold together, and not break in pieces when the shot struck the plates. So he came to the conclusion that steel shot and shell were the only projectiles suited for attacking iron-plated vessels. Major Palliser, however, has recently succeeded in demonstrating most thoroughly and practically, that, by his method of chilling the shot when cast, he obtains a metal possessing a hardness equal to that of steel and a toughness approaching very closely to that of wrought-iron. He has thus solved one of the most important questions of modern gunnery, — that of penetrating armor with shells which do not explode until they have passed through the plate and backing, or, in other words, completely through a ship's side. Major Palliser is by no means the first to accomplish this object: the credit of that is due to Mr. Whitworth, who effected his purpose with comparatively small projectiles and low charges of powder. Following the latter gentleman, others have done the same thing; but two serious drawbacks to success were always present. The shells for the most part exploded backward on contact; and being made of steel, were very expensive, their cost for large ordnance ranging from £7 to £20 each projectile. So, on the score of imperfection and of costliness, absolute success was not attained by any, nor, until Major Palliser had perfected his chilled shot, which are both cheap and efficient, was it considered attainable. But the question was set at rest by a series of experiments which were carried out last week, at Shoeburyness, with various kinds of shell.

These experiments were instituted for the purpose of testing Major Palliser's chilled shells against those of the best steel projectiles, and in their results proved most valuable. The principle upon which Major Palliser manufactures these shells is worthy of notice, as being something more than the old process of chilling. As the shells are required for a particular purpose, they must have something more than a mere chilled surface; a definite and carefully determined hardness must be imparted throughout the metal. This condition is attained by a selection and combination of those brands of iron which have been found by experiment to chill to the exact extent required, a careful mean being observed between iron which it is difficult to chill and that which chills too hard. Added to the principle of manufacture, is the principle of construction, which goes far toward the success of the projectile. The form given by Major Palliser is such as will convert the sudden shock of impact as much as possible into a uniformly increasing pressure. In other words, the projectile has an elongated, pointed head, which is as essential an element in it as is the perfect chilling of the metal. Upon the occasion in question, the firing was from an ordinary seven-inch wrought-iron muzzle-loader, with full battering charges of twenty-two pounds of powder, and a range of two hundred yards. The shells were directed against a "Warrior" target, which was built of the

ordinary four-and-a-half-inch plate, with eighteen inches of teak backing, and an inner iron skin; the whole well braced and strengthened. Half the target was bolted on Mr. Bascomb's plan of India-rubber pads, the other half of the bolts being secured by Mr. Paget's steel cup washers. At the conclusion of the experiments it was found that Mr. Bascomb's system had stood better than Mr. Paget's; but then it appears that the shots almost invariably struck that part of the target bolted on Mr. Paget's principle, while that portion fastened with Mr. Bascomb's washers was scarcely touched. The experiments were commenced by firing a steel shell on Major Alderson's plan, having a screwed base, and being charged with three pounds of loose powder. The shell penetrated the four-and-a-half-inch plate, but did no more, except to explode backward from the face of the target.

The next shell, which was of the best steel, of Mr. Firth's, passed through the plate and entered the wood backing, but it exploded outward as the first had done. The third shell struck on the edge of the hole made by the first, passing easily through and exploding in the teak backing, which it set on fire. Other shells were tried, with similar results, in some instances; in others they were even less satisfactory, some of Mr. Firth's shells bursting before they reached the target: a few exploded in the gun. Three of Sir William Armstrong's conical-headed shells, made on the Belgian pattern, with a sharp cone, were fired, and produced a similar effect to those previously fired. After all the steel shells had been tried, Major Palliser's chilled-iron shells were tested, and the first shot proved the superiority of the system over all the others. The shell struck an uninjured portion of the target, and went through the plate and backings so quickly as not to explode until it had passed beyond. The backing where the shell had passed through was splintered into fragments; and had the object been the side of a ship, instead of a target, the results would have been most damaging to a gun's crew at quarters. The charge of the second Palliser shell did not explode; but, after passing through the target, the projectile broke itself up into fragments, which were sent spinning about in all directions with a velocity nearly as dangerous as an explosion would have imparted to them.

The results of these two shots were so conclusive that the charge of powder was reduced to eighteen pounds, with which the third shell was fired. This shell missed the target, and went away to sea; the next, however, which was fired without a bursting charge, went through the target, breaking up and scattering its fragments as before. The charge was then further reduced to sixteen pounds of powder, which was nearly equal to increasing the range from two hundred yards to one thousand yards, while the velocity of each shot, on striking, was less than thirteen hundred feet per second. But for all this, the next shell penetrated the plate and backing, and was only stopped by coming in contact with one of the heavy struts which supported the target from behind, and which it broke. At this stage of proceedings, the Ordnance Select Committee ordered the firing to cease, considering a continuation would only be a waste of time and powder. This

will be the more apparent when we state that, a few weeks since, Major Palliser's projectiles were tried against the "Bellerophon" target, which has six inches of iron, with twenty-two inches of teak, and an inch iron inner skin. The results, however, were precisely similar to those with the "Warrior" target, the shells passing through quite as easily. The results, therefore, constitute a victory for guns over armor-plates, and this long-pending question may be considered for the present as definitively settled. For the present we say, because, although the "Warrior's" strong sides afford but little more protection against Major Palliser's shells than would those of a wooden ship, it is possible that we may in time find some means of neutralizing the damaging effects of these projectiles. It always has been so; throughout the history of the question, victory has always alternated between the guns and the plates. But, unquestionably, Major Palliser has gained such a victory as will not easily be reversed, and has inaugurated such a condition of things as will require a long time and a considerable amount of scientific and engineering skill to render obsolete.—*Mechanics' Magazine.*

CHILLED SHOT AND THE SHOEBURYNESS EXPERIMENTS.

As the facts come to hand, it is apparent that the success of the shots made by the nine-inch gun at Shoeburyness, on the 20th of September, was due mainly to the character of the projectile, and not to the gun nor the charge of powder. The Palliser shot and shell are made of chilled iron, which has been pretty satisfactorily proved to be superior in penetrating qualities to either wrought-iron, ordinary cast-iron, or steel. Both steel and chilled shots were used in these experiments, but while the hardened-steel shots failed to penetrate through the target, and either broke in pieces, or were compressed and bulged out of shape, every one of the chilled-iron shots did effective service, never in one instance changing in form.

The target used was about forty feet long by eight feet high, built of single thickness of rolled wrought-iron, eight inches through, bolted by the Palliser screws to a backing of eighteen inches of teak timber and an inner plate of three-quarters of an inch iron. The whole was sustained by heavy timber backs. The face of the target was not in one plane, but half of its length was inclined at an angle of thirty degrees to the other half, the line of fire being the same in both cases; so that a shot against the inclined face would make, with the target, an angle of sixty degrees. The gun was a nine-inch muzzle-loading rifle, with increasing twist of thread, throwing shot of two hundred and fifty pounds with charges of forty-three pounds of powder. The distance fired was two hundred yards.

The steel shot were cylinders having either pointed heads struck on a circle the diameter of the shot, flat heads, or the Belgian or ogee head. All of them were hardened in prussiate of potash and oil, or water. Some of them were solid, others shells with the head screwed into the body, or the base secured in the same man-

ner. Out of twenty-four shots, twelve were of this character. Not one of them passed through the target, and every one was either broken into fragments or bulged out of shape.

The Palliser chilled shots in every case penetrated the iron plate, and in one instance, on the square face of the target, went entirely through plate, backing, and lining, and lodged in a pile of iron plating, brick, and stone masonry, twelve feet in the rear of the target. In no instance was the form of the shot changed. The Palliser shots and shells have heads formed on a radius of one and a half diameters of the cylindrical portion. Whenever the Palliser shots struck the inclined face of the target they penetrated, while the cast-steel shots sometimes glanced off.

One circumstance in this trial is remarkable. The steel shots were so hot after striking the target that they could not be handled, while the chilled shots were barely warm. This, with the fact of the change of form in the steel projectiles, proves that much of the energy of the shot had been expended in this direction, instead of in penetration.

While the velocity of the shots fired in our Fortress Monroe experiments exceeded in no instance 1,155 feet per second, that of those in this Shoeburyness trial ranged from 1,260 to 1,340 feet per second. At such an initial velocity, with a distance of only two hundred yards between the gun and target, it ceases to be very surprising that it was possible to throw shot through such a barrier. — *Scientific American.*

PENETRATION OF SHOT, AND RESISTANCE OF IRONCLAD DEFENCES.

Captain Noble has lately carried out a series of experiments under the direction of the Ordnance Select Committee, for the purpose of determining various points connected with the resistance of iron plates, and his paper forms part of a report which he has submitted to the committee.

The above series of experiments were instituted for the purpose of determining the following points: 1st, To determine the relative penetrating effects of two steel shots on an iron plate, provided they strike with the same "work" or mechanical effect, notwithstanding the one may be heavy, with a low velocity, and the other light, with a high velocity. 2d, To determine the relative resistances of a plate to penetration, by two steel shot of similar form of head, and striking with "work" proportional to their respective diameters. In order to determine the first point, the committee fired a number of hemispherical-headed steel shot from a muzzle-loading gun of 6.3-inch calibre, at 4½ and 5½-inch unbacked plates, the weights of the shot being different, viz., 35 lbs., 70 lbs., 106 lbs., and the diameters the same, viz., 6.22 inches. The charges with which these projectiles were fired were arranged so that the "work" was the same in each case, — that is to say, the velocity on impact of the light shot was much greater than that of the heavy shot, while the expression W v^2, weight of shot multiplied by the square of its velocity, was con-

stant. The results of these experiments were very interesting, and are fully detailed in the tables which accompany Captain Noble's report.

The conclusions which have been drawn from these results will be given when the second point has been considered. To determine this question, viz., the relative resistance of a plate to penetration by two shot of similar form of head, and striking with "work" proportional to their respective diameters, the committee fired a series of steel hemispherical-headed shot, of various weights and diameters, at 4½ and 5½-inch unbacked wrought-iron plates, the velocities being so arranged that each projectile should strike with a work proportional to its diameter. Thus, suppose the comparison to be made between a 7-inch shot animated with a "work" represented by 1,000, and a 9-inch projectile, the latter should strike with a "work" represented by 1,286, or in the proportion of 9 to 7. Having finished the details of these experiments, Captain Noble proceeded to consider the effects of shot striking a plate obliquely or at an angle. A small number of experiments have lately been made in connection with this part of the subject, and, although further trials are necessary, the general results go to prove that the power of perforation possessed by the shot is diminished in the proportion of the sine of the angle of incidence to unity.

The subject of cast-iron projectiles next claimed attention, and Captain Noble explained the difference between the effects of cast-iron and steel shot. With the former, much of the total "work" is expended in breaking up the projectile on striking, and hurling the pieces in different directions, whereas, when the shot are carefully manufactured of the very best steel, very little "work" is done on the projectile, and, in some instances, the material of the shot has been so perfect, that its alteration of form after penetrating the plate has been almost inappreciable.

From this subject Captain Noble passed to the consideration of the proper form and material of projectiles to be used for the penetration of iron-clad defences. It has been clearly demonstrated by numerous experiments, that ordinary cast-iron is almost useless as a material for the manufacture of the above projectiles. Steel is an excellent material for shot, but it is also most expensive; and, as recent experiments have shown that Palliser's chilled iron is almost, if not quite, as good as steel, we shall probably use this material for solid shot, and employ steel for shells alone. Various forms of head have been proposed for steel projectiles. Thus, we have had the flat head, relied on by Mr. Whitworth, the round head, elliptical head, etc. The flat head has gained a great reputation, from being the shape used by Mr. Whitworth in his first experiments against the "Warrior" target. Of all these forms, however, Captain Noble prefers the pointed, or ogival head; and he described, by means of a diagram, the difference in effect between the pointed and the blunt form. The blunt, that is, flat-headed or round-headed shot on striking an iron-clad structure, such, for instance, as the "Warrior," punches a piece of armor out of the plate, and drives it into

the backing; the shot, however, has no means of ridding itself of this piece of plate, and, consequently, has to push it in front of it through the backing. It is needless to remark that this piece of jagged armor-plate must greatly increase the resistance which the shot meets in passing through the backing. When, however, the shot is of the form of a pointed ogival, the results of its action are far different; this projectile cuts, or rather tears, through the armor-plate, and the pieces of broken plate are bent back and forced into the backing round the edge of the hole; the shot then passes through without carrying any jagged armor in front of it. Captain Noble then proceeded to give a short detail of some late experiments with pointed shot and Alderson's solid-headed steel shell, which goes to prove that this form is much superior to any hitherto tried.

The subject of iron-clad ships was then entered on, and a brief summary given of the experiments against targets representing actual vessels. The conclusions which might be drawn from the whole of the experiments were; 1st, Where it is required to perforate the plate, the projectile should be of a hard material, such as steel or chilled iron. 2d, The form of head best suited for the perforation of iron plates, whether direct or oblique, is the pointed ogival. 3d, The best form of steel shell is that in which the powder can act in a forward direction, and which is furnished with a solid steel head, in the form of a pointed ogival. 4th, When chilled iron can be made of the best quality, it is almost, if not quite, as effective as steel for solid shot, and, where the projectile can perforate with ease, the chilled shot is more formidable than steel, as it enters the ship broken up, and would act as grape. 5th, To attack well-built iron-clads effectually, the guns should be, if possible, not under 12 tons weight and 9-inches calibre, firing an elongated projectile of 250 lbs., with about 40 lbs. of powder. 6th, When the projectiles are of a hard material, such as steel, the perforation is directly proportional to the "work" in the shot, and inversely proportional to the diameter of the projectile; and it is immaterial whether this "work" be made up of velocity or weight, within the usual limits which occur in practice. 7th, The resistance of wrought-iron plates to perforation by steel projectiles varies as the square of their thickness. 8th. A plate at an angle diminished the effect as regards power of perforation in the proportion of the sine of the angle of incidence. 9th, The resistance of wrought-iron plates to perforation by steel shot is not much, if at all, increased by backing simply of wood; it is, however, much increased by a rigid backing, either of iron combined with wood, or of granite, iron, bricks, etc. 10th, Iron-built ships, in which the backing is composed of compact oak or teak, offer much more resistance than similarly clad wooden ships. 11th, The best form of backing seems to be that in which wood is combined with horizontal plates of iron, as in the "Chalmers," "Bellerophon," and "Hercules" targets. 12th, An inner iron skin is of the greatest possible advantage; it not only has the effect of rendering the back more compact, but it prevents the passage of many splinters which would otherwise find their way

into the ship; therefore, no iron-clad, whether iron-built or wooden-converted, should be without an inner skin. 13th, The bolts known as "Palliser's bolts" are the best for securing armor plates. In these bolts the diameter of the shank is reduced to that which it is at the screwed end. The author of the paper preferred the English punching system of high charges with small shot to the American racking system of heavy cast-iron shot propelled with low charges, on the ground that by the former method, a ship might be sunk, or some vital part injured, in much less time than would be required to destroy her by the American system.—*Report of British Association*, 1866.

NATURAL PHILOSOPHY.

THE NEW THEORY OF LIGHT.

The following are extracts from a letter to the "Reader" by J. G. Macvicar, on Professor C. Maxwell's electro-magnetic theory of light, of which he says: "A slight inspection is sufficient to show that it sets the seal of mathemetical consistency and prestige upon ideas which must modify profoundly all our popular ideas on solar radiation. With regard to light, it sanctions the idea that it is an electro-magnetic phenomenon, and such, therefore, that it must observe the laws and produce the phenomena of what is commonly known as polarized action. And does not this view at once relieve speculative astronomy of some of its greatest difficulties, and open the way for a happy explanation of some of the most remarkable but still unexplained phenomena of the heavens?

"Thus, our first physicists, taking for granted, as to the solar action, the hypothesis of an universal and indiscriminate radiation in all directions into space (or in accordance with modern science, let us say into the ether) by such a body as the sun, just as if he were a spherical gong poised in compressed air, and struck from within simultaneously all round, have been bestowing of late years infinite pains to explain how his brightness is kept up during all time, without any loss, so far as can be discovered. But, if not gross mechanical undulations to and fro in compressed air, but a rhythmical action in ether — electro-magnetism, in short — is to be the type to which light and radiant heat are to be referred, then there will be no waste of solar action at all, and there need be no more concern about the permanence of the sun's brightness. For if the solar action, with respect to which, so far as observation goes, we know only that it illuminates the various members of our planetary system, be of an electric or electro-magnetic nature, then, after having induced a similar state of action in the medium immediately surrounding him, — that is, after having surrounded the central orb with a photosphere, — it will render the ether immediately beyond almost, and soon altogether, non-conducting in all directions, except those in which bodies in a dissimilar state present themselves, — that is, the sun will be insulated in the ether, except in the direction of planets, satellites, meteorites, etc. In all other directions, his action will be conserved. And even in the direction, in which he radiates to a distance, he will receive back again as much as he gives away. Such is the well-known phenomenon of electrical and magnetic action. In exchange for the light and heat which the sun gives to the planets, he will receive from them a negative, reciprocal

complemental or harmonic action, by which his own will be sustained or increased or diminished, according as the amount of dissimilarity existing between him and them is greater or less at the time. The solar radiation proper to the same column of space will be more intense in winter than in summer, and in the arctic regions than in the torrid zone.

"Again, it is a serious undertaking to explain on the hypothesis of universal and indiscriminate radiation, diminishing as the square of the distance increases, the brightness or even the visibility to us of the distant planets. But what we observe in nature is precisely what we should expect on the electro-magnetic theory of light. The remote planets, by being placed in positions which would tend to involve them in coldness and darkness, are thereby rendered in these respects more dissimilar to the central orb; they will therefore be all the more illuminated and warmed by him; and the climate of the most remote members of our system may possibly be as genial, and their day as bright, as ours.

"Again, since all the bodies between which and the sun, according to this theory, action and reaction take place, circulate in planes corresponding to low latitudes in the sun, a reason appears why these regions of the solar disk should be peculiarly the regions of storms in his photosphere; and the way is open to a theory of sun-spots and faculæ in a direction in which indeed a step has been made already by Mr. Balfour Stewart, in connecting certain states of the solar illumination with the positions of the planet Venus."

VELOCITY OF LIGHT.

The observations of the eclipses of Jupiter's first satellite, and those of the phenomena of aberration, lead directly, although with a different degree of approximation, to the determination of the time light occupies to run over the mean distance of the sun from the earth. To deduce from this the absolute value of the velocity of light referred to our ordinary units of length, we must know how many miles are contained in the distance from the sun to the earth. The value of this distance is found by means of the parallax of the sun; we designate thus the angle under which, being at the sun's centre, we would see the radius of the earth. The sun's parallax, calculated from the observations of the last transit of Venus over the disk of the sun, is fixed at 8.57 seconds; hence the distance of the sun from the earth is equal to 24,109 times the radius of the earth, or to 95,384,900 miles. As this length is run over by the light in 8 minutes 18 seconds, or in 498 seconds, we conclude that the velocity of light is 191,391 miles in a second.

However, for some years, several circumstances have conspired to make us believe that the determination of 8.57 seconds given as the value of the sun's parallax is too small, and that the parallax ought to be augmented by a quantity not less than the thirtieth of its value, which would elevate it to about 8.9 seconds. From

this increase in parallax results a diminution in the earth's distance from the sun, and consequently in the distance gone over in 8 minutes 18 seconds by the light; the velocity of light will therefore be reduced to a little less than 186,420 miles in a second. The next transit of Venus, which will happen in 1874, cannot fail to set at rest all doubts which may yet remain on this point. — DELAUNAY, *in Scientific American.*

MECHANICAL EQUIVALENT OF LIGHT.

Professor Thomsen of Copenhagen has ascertained that the mechanical equivalent of light, of the luminous radiation as distinct from the obscure radiation, from the flame of the French standard bougie is as nearly as possible 1.74 kilogrammetres per minute, being about 1-50 of the mechanical equivalent of the total radiation from the same flame. A writer in "Cosmos" has calculated from this the mechanical equivalent of the total light of the sun. He finds it to amount to something like that of 1,230 septillions of bougies, or to 35 billions of tons lifted a billion of kilometres per second — the lifting of 35 billions of tons (French) a billion of kilometres being about equal to lifting the weight of the earth 20 feet.

COLOR OF SUNLIGHT.

M. Memorski, of Vienna, confirms M. Brucke's observations, that diffused solar light, instead of being perfectly white, is tinged with red, just as the flames of gas or lamps are tinged with yellow. Diffused light, received at noon through a cloudy sky, deviates by one twenty-second part of the chromatic circle from the extreme red of the spectrum toward the violet. The light of burning magnesium, which appears to be so like sunlight, has also a tinge of violet.

COLORS IN THEIR RELATION TO ARTIFICIAL LIGHT.

Never select colors in the evening, is an old maxim, whose value can be attested by many a disappointed purchaser, who, ignorant or disregarding this advice, and deeming himself the favored possessor of some tint of rare excellence, discovers, on the return of daylight, a color far from equalling his anticipations. The artist, overtaken by darkness, hastens to apply the last touches to some masterpiece; but the morning light reveals how poorly his intentions have been realized. The cause of this inconstancy is explained, and a remedy suggested, in a late article in the "Photographic News."

From the spectral analysis, we learn that the flames of our lamps or gas-lights contain sodium, which, in burning, yields a yellow flame, as strontium gives a red, and iridium a blue flame. Now, when the color blue is illuminated by the yellow light, it appears green; but if the flame strikes a color complementary to

yellow, it will appear white or black, according as the body has, or has not, the power of reflection; which is equivalent to saying that this flame alters the nature of colors, deepening the hues of some, and extinguishing others.

Take a spirit-lamp and put into it a piece of common salt; the wick will soon become saturated with sodium in solution; the flame, in consequence, will be yellow, and all colors will assume a monotonous white, black, or gray. It is only when this substance is in excess that we have the total extinction of colors, but a flame less rich will produce a partial extinction, and this is the reason why colors are at all visible by gas-light. It may be asked, whence does illuminating gas derive this sodium? From the coal; from the water with which the gas was washed; it comes also from matters employed in its purification, and probably even from the atmosphere.

The only hues which resist only slightly the yellow flame, are furnished by the blue; all the other colors are profoundly modified. Fortunately, the flames which serve as sources of light are never saturated with sodium, hence the effects are greatly modified.

The light from the burning of magnesium alone brings out the various colors, both natural and artificial, in the same hues as they appear by daylight. The services of chemistry render, then, to painting, not only colors more or less rich, but also it has endowed it with a mode of lighting, whereby the painter may be able to work at night without incurring mistakes or illusions. — *Scientific American.*

SPECTRUM OF AQUEOUS VAPORS.

M. J. Jannsen has just communicated to the Academy of Sciences a memoir "On the Spectrum of Aqueous Vapor." His observations were made with an iron tube thirty-seven metres long, filled with steam, under a pressure of seven atmospheres; the light was furnished by sixteen gas jets. The spectrum showed five dark bands, of which two, well marked, answered to D and A (Fraunhofer), and reminded the observer of the solar spectrum seen in the same instrument toward sunset. According to the first comparisons made between the spectrum of steam and that of solar light, it appeared that the group A, B (in great part, at least), C, two groups between C and D, are due to the aqueous vapor in the atmosphere. Another interesting result was given by the spectrum. The spectrum was very dark at the violet end, and brilliant in the red and yellow, showing that aqueous vapor is very transparent to the latter rays, and suggesting that it will appear orange-red by transmission, and redder, according to the thickness of the layer. This result requires to be carefully verified, and, if established, will explain the redness always observed at sunrise and sunset. He hopes soon to be able to pronounce upon the existence or non-existence of aqueous vapor in the atmosphere of the planets and other stars: at present he can only say, that it does not exist in the atmosphere of the sun.

COMPLEMENTARY COLORS.

The production, by M. Niépce St. Victor, of black in photography, by means of complementary colors, has given rise to researches on the subject by M. Chevreul, who found that, although complementary radiations of the spectrum produce white, those radiations which emanate from complementary coloring matters, applied in succession or simultaneously to the cloth, etc., afford, according to the accuracy of the proportions, black, brown, or gray. Thus, a blue pattern printed on orange will appear black. This subject, when fully developed, may have a most important bearing on arts and manufactures.

NEW POLARIZING PRISM.

MM. Hartnack and Prazmowski recommend deviating from the form of the Nichol prisms. The shape they recommend is shorter, and has both ends normal to the incident and emergent rays. According to the cementing substance employed, they give the following angles: With Canada balsam, refracting index 1549, the faces of the Iceland spar make with the plane of section an angle of 79°; with balsam of copaiba, index refr. 1507, the angle is 76°.5; with linseed oil, index refr. 1485, the angle is 73°.5; rich poppy oil, index refr. 1463, 71°.1. The two middle ones give the largest angle of the field, viz., 35°.

WHY THE SKY IS BLUE.

It is generally supposed that the blue color of the sky is due to moisture in our atmosphere; and the idea seems to be confirmed by the intensity of the color during the moist weather of summer, when compared with the sky of the more dry-weathered winter. It has recently been shown by Prof. Cooke, of Cambridge, in a paper read to the American Academy of Arts and Sciences, that this view is correct. He has found, by means of the spectroscope, — a very delicate instrument of analysis, by which the most minute substances, even when at a distance, can be detected, — that the aqueous vapor of the atmosphere absorbs most powerfully the yellow and red rays emanating from the sun, leaving the blue rays to be transmitted, and thus accounting for the color of the sky. The instrument also proves that the color is due to simple absorption of these rays by the water, and not to repeated reflections from the surface of an infinity of drops, as has been supposed.

DEFECT IN THE POLARISCOPE, WITH A SIMPLE AND EFFECTIVE REMEDY.

The author stated, that, having been engaged in some experiments with polarized light, projected on a screen by means of the oxy-hydrogen lantern, he discovered that even the best instruments which were constructed were inefficient, inasmuch as none but the axial rays transmitted through the condensers were polarized, the main body of the luminous cone undergoing reflection

from the polarizer without being really polarized. He remedied this by intercepting the light with a flint concave lens before it reached the polarizer, so that the whole mass of rays, being projected in a parallel direction, was completely polarized. On leaving the polarizer, the rays were again converged, before passing through the crystal, or other object to be exhibited, by a small achromatic lens, which thus acted as an achromatic condenser. It was stated that this arrangement effected a most important increase in the brilliancy of the object exhibited on the screen. — J. TRAILL TAYLOR, *in Reader*.

COMPARATIVE INTENSITY OF THE LIGHT OF THE MOON AND OF VENUS.

On June 20, 1865, at 3 A. M., the moon and Venus were in conjunction, in the latitude of Lyons, France, so that both bodies could be seen in the same field of vision. This afforded an opportunity of comparing the light received from them. The surfaces taken for comparison were those affording rays at the same angle of incidence; and, on the moon, the region was that between the craters Rocca and Eirchstadt, over the very brilliant surface to the southeast of Grimaldi. It was found that the light from this brightest part of the moon was only one-tenth of that reflected by the surface of Venus. — CHACORNAC, *in Comptes Rendus*, 58.

TRANSPARENCY OF THE SEA.

Father Secchi has come to the following results, from experiments made near Civita Vecchia, at from six to twelve miles from the coast, the sea being clear and calm. It was found that the maximum depth at which a white disk, ten feet in diameter, was visible from the surface, when the sun was sixty degrees above the horizon and the sky clear, was about one hundred and forty feet. In descending, white disks appeared first of a light green color, next of a clear blue, then the blue became gradually darker, until, at the depth mentioned, they could not be distinguished. Yellow or sand-colored disks, ceased to be visible much sooner than white disks, becoming invisible at depths varying from fifty-five to eighty feet, according to their tint.

CURIOUS EXPERIMENT.

The following good lecture experiment has been suggested by M. J. Nicklés. With the following pigments, he paints a spectrum, which shows all the colors, either by gas or candle-light; but shows only black and white, with a soda flame (alcohol and salt).

Color by daylight.	*Pigment.*	*Color by soda flame.*
Red,	Ochre,	Black.
Orange,	Biniodide of mercury,	White.
Yellow,	Chromate of lead,	White.
Green,	Manganate of baryta,	Black.
Blue,	Aniline blue,	Black.

NEW INSTRUMENT FOR MEASURING DISTANCES.

Dr. Emsmann, in a paper in "Poggendorff's Annalen," describes a new instrument for measuring distances, which differs from all previous arrangements, by being independent of the measurements of angles, or of a base line. It consists, simply, in an application of the well-known principle, that the image of an object is brought to a focus by a convex lens at a distance from the lens varying according to the remoteness of the object. The arrangement described by Dr. Emsmann consists of an object-glass of thirty seconds and an eye-piece of one second focal length, a screen of ground glass, upon which the image is received, being placed behind the eye-piece. The instrument, it will be seen, resembles in principle a photograph camera; the length, however, is about five and one-half feet. In order to keep the indications within certain limits, the screen is placed behind the eye-piece, and the distance between the lenses is so arranged that a variation in the distance of twenty-five paces, at all ranges, requires, at least, a movement of one line in the screen. Trustworthy readings may be obtained up to two thousand paces. Dr. Emsmann suggests that the instrument will be found useful in coast batteries, for measuring the distance of a vessel out at sea. In siege operations, the time generally admits of the measurement of a base line, the distance of the enemy's works being calculated by trigonometry. Should there be no practical difficulties in the way, it might probably replace, with advantage, the stadiometer, which depends on the principle of similar triangles, supplied the army for use in judging distance-drill.

THE CYCLOSCOPE.

In places where railways are most needed, but where, owing to disadvantages of the ground, and other hindrances, the transport and use of large instruments is very difficult, an instrument at once portable, and capable of replacing a theodolite in setting-out railway curves, becomes a desideratum. An instrument called a "Cycloscope," or curve-tracing instrument, invented and patented by Mr. H. Temple Humphreys, associate of the Institute of Civil Engineers, is calculated to meet this want, by measuring angles and setting out railway curves with increased facility. It may be shortly described as an instrument combining the advantages of a pocket-sextant with the principles of a kaleidoscope. When the two plane mirrors of an ordinary pocket-sextant are turned toward a distant object, so that by one combined reflection between both mirrors a reflected image of the object is obtained, the angular interval between the image and the object is twice the angle contained between the mirrors. Repeated reflections of the same kind would, of course, produce a series of images, growing dimmer, arranged at the same angle from each other as the first image from the object. This is found to be the case when the object is indefinitely distant. When the object is near, as in the common kaleidoscope, and placed between the mirrors, it is seen

repeatedly reflected in the mirrors at equal intervals along the circumference of a mathematically true circle, the centre of which is the intersection of the mirrors. In all positions whatever, of an object viewed by reflection with two plane mirrors, this actually remains true. The object appears the first of a series of images arranged at equal intervals round the circumference of a circle, the centre of which is the point of intersection of the mirrors with each other, or of the images, if need be, produced. Of the two plane mirrors with which the cycloscope is entirely composed, the front mirror is half silvered, and it is brought into any convenient inclination with the entire mirror behind it, by turning a screw. The parts of a revolution of the screw correspond to minutes of a degree of inclination. When the last chained peg of the straight line immediately preceding a railway curve is seen directly through an eye-hole in the centre of the entire mirror, its successive combined reflections at the same time meet the eye at equal tangential angles, and trace out a circle, the direction of the intended curve. The curve can then be set out by pegs placed at equal chained distances apart, in the direction of the combined reflections. By this means several points of a railway curve can be set out at one sight, and the necessity of repeated removal and readjustment of a theodolite in the ordinary mode of setting out railway curves is avoided. The instrument, which is made by Mr. Stanley, London, resembles a pocket-sextant in being also a small and portable construction for measuring distances and angles of moderate width.—*Intellectual Observer, May*, 1866.

OPTICAL DELUSION.

Many of our readers will, no doubt, recollect "Eidos Æides," which was performed at Her Majesty's Theatre during the winter. It has been made the subject of a patent by the inventor, Mr. Maurice, from whose specification we learn the manner in which this clever delusion is produced. It is perhaps necessary to say that it consists in causing an actor, or an inanimate object which is in full view of the audience at one moment, to disappear instantly, and then to reappear with the same rapidity. The means by which this is accomplished are very simple, and are, to some extent, similar to those used in exhibiting "Pepper's Ghost." A sheet of plain unsilvered glass is placed upon the stage, either upright or inclined at a suitable angle, at the place where the actor or object is to disappear. This glass is not perceived by the audience, and it does not interfere with their view of the scenery, etc., behind the plate. A duplicate scene, representing that part of the back of the stage covered by the glass, is placed at the wing, out of sight of the spectators. With the ordinary lighting of the stage, the reflection of this counterfeit scene in the glass is too faint to be observed; but when a strong light is thrown upon the scene, the stage lights being lowered at the same time, the image becomes visible. This duplicate scene being an exact fac-simile of the background of the stage, the change is not noticed by the audience, the only difference being that they now see by reflec-

tion that which they saw a moment previously by direct vision. The actor, standing at a sufficient distance behind the glass, is completely hidden from view, and he is again rendered visible by turning down the light on the false scene, and allowing the stage lights to predominate. When "Eidos Æides" was being performed at Her Majesty's Theatre, it was, however, possible, with a good opera-glass, to distinguish the outline of the figure behind the plate. The effects produced may, of course, be modified. An actor may be made to appear walking or flying in the air, or dancing on a tight-rope, by eclipsing or obscuring a raised platform on which he may be placed. — *Reader.*

WHY BEES WORK IN THE DARK.

A life-time might be spent in investigating the mysteries hidden in a bee-hive, and still half of the secrets would be undiscovered. The formation of the cell has long been a celebrated problem for the mathematician, whilst the changes which the honey undergoes offer at least an equal interest to the chemist. Every one knows what honey, fresh from the comb, is like. It is a clear, yellow syrup, without a trace of solid sugar in it. Upon straining, however, it gradually assumes a crystalline appearance; it candies, as the saying is, and ultimately becomes a solid lump of sugar. It has not been suspected that this change was due to a photographic action; that the same agent which alters the molecular arrangement of the iodide of silver on the excited collodion plate, and determines the formation of camphor and iodine crystals in a bottle, causes the syrupy honey to assume a crystalline form. This, however, is the case. M. Scheibler has enclosed honey in stoppered flasks, some of which he has kept in perfect darkness, whilst others have been exposed to the light. The invariable results have been that the sunned portion rapidly crystallizes, whilst that kept in the dark has remained perfectly liquid. We now see why bees are so careful to work in perfect darkness, and why they are so careful to obscure the glass windows which are sometimes placed in their hives. The existence of their young depends on the liquidity of the saccharine food presented to them, and if light were allowed access to this, the syrup would gradually acquire a more or less solid consistency; it would seal up the cells, and, in all probability, prove fatal to the inmates of the hive. — *Chronicle of Optics, in the Quarterly Journal of Science.*

NEW ARTIFICIAL LIGHT.

Mr. James Wilkinson, of Chelsea, is endeavoring to rival the magnesium light for photographic purposes, by means of a mixture of phosphorus and nitrate of potash. He recently burnt a quarter of a pound of this mixture in his garden, at night, with a view to obtain a photograph of a wind engine which was being erected in an adjoining garden, and he states that "the length of time from when it was first lit until it was finally burnt out, was nearly six minutes. The utmost cost was a fraction over four-

pence. The reflection of the light might be seen for two miles round. So bright was it that the fire-engine authorities mistook it for an ordinary conflagration, and hurried their engines to the spot. On finding no trace of the fire they returned, rather chagrined; not, however, without first satisfying themselves by a thorough examination of the premises. All around appeared one blaze of light; the sky looked like a mass of fire." The picture taken during this startling illumination "came out," we are told, "with great sharpness and vividness, the houses near being brought out prominently. It, in fact, equalled any picture taken on a bright day."—*Mechanics' Magazine.*

THE MICRO-SPECTROSCOPE.

The micro-spectroscope has received its first application to medico-legal purposes, in the examination for blood stains of the hatchet supposed to have been used in the Aberdare murder. Dr. Bird Herapath, F.R.S., who was retained by the Crown, placed sections of the handle in distilled water, and submitted the solution obtained to an examination in this instrument. Within the green, and on the border of the yellow rays, the well-known characteristic dark bands of blood were produced. Only one other substance was known to produce similar dark bands,—cochineal dissolved in ammonia,—in which case, however, their position would be different. Dr. Herapath said he was satisfied, from the evidence this test had afforded, that the hatchet had been stained with blood.

INVISIBLE PHOTOGRAPHIC IMAGE.

M. Carey Lea of Philadelphia communicates to the "American Journal of Science," for July, 1865, the following paper:—

"Some experiments in which I have lately been engaged seem to me to finally settle the long-contested question as to the nature of the invisible photographic image, and I hasten to send a very brief description of them.

"The view that the change which takes place in an iodo-bromized plate in the camera is a purely physical one, that no chemical decomposition takes place, and neither liberation of iodine nor reduction of silver, has obtained a pretty general acceptance. But latterly it has been opposed by two distinguished photographers, Dr. Vogel and Major Russell. The former affirms that iodid of silver is never sensitive unless there is a body present capable of taking iodine from it under the influence of light; and Russell believes that the developed image is chiefly produced at the expense of the silver haloid in the film. The following experiments seem to me to decisively close this controversy in favor of the physical theory.

"*Experiment* 1.—If the iodid or bromid of silver in the film undergoes decomposition in the camera, and, still more, if the developed image is formed at its expense, the film of iodo-bromid must necessarily be greatly consumed in the development under

the dense portions of the negative, which it has contributed to form.

"To settle this point, I exposed and developed an iodo-bromized plate in the ordinary manner. Then, instead of removing the unchanged iodid and bromid by fixing in the ordinary manner, I took measures to remove the developed image without affecting the iodid and bromid. This I succeeded in doing with the aid of a very weak solution of acid per-nitrate of mercury. Now, if the iodid, or bromid, or both, had been in any way decomposed, to form or aid in forming the developed negative image, when this came to be removed, there should have been left a more or less distinct positive image, depending upon varying thicknesses of iodid and bromid in the film, much like a fixed negative that has been completely iodized. Nothing of this sort was visible; the film was perfectly uniform, just as dense where an intense light had been, as in those parts which had scarcely received any actinic impression, and looking exactly as it did when it first left the camera, and before any developer had been applied. This experiment seems sufficiently decisive. But the following is far stronger.

"*Experiment* 2.—A plate was treated in all respects as in No. 1, except that the application of the nitrate of mercury for removing the developed image was made by yellow light. The plate, now showing nothing but a uniform yellow film, was carefully washed, and an iron developer, to which nitrate of silver and citric acid had been added, was applied. In this way the original image was reproduced, and came out quite clearly with all its details. Now, as every trace of a picture and all reduced silver had been removed by the nitrate of mercury, it is by this experiment absolutely demonstrated that the image is a purely physical one; and that, after having served to produce one picture, that picture may be dissolved off, and the same physical impression may be made to produce a second picture by a simple application of a developing agent.

"I have repeated the experiment with a pyrogallic development with similar results. Both the first and second developments may be made with an iron developer, or both with a pyrogallic. The experiment succeeds without the least difficulty in either way."

The same author, in "Silliman's Journal" for September, 1866, concludes a paper on this subject, as follows: "I have endeavored to show that the action of light upon pure iodide of silver isolated cannot be a chemical reduction: 1. Because that effect, even when carried many hundred thousand times further than in the ordinary photographic processes, perfectly disappears in a few hours, spontaneously, under circumstances which render it impossible to suppose that iodine could have been restored to replace that which (had reduction taken place) must have been disengaged. 2. Because, even where the action of light is prolonged many hundred thousand fold the ordinary time, no reduced silver nor sub-iodid can be detected as present. 3. I have shown that another metal, mercury, is capable of developing these images

as well as silver. 4. I have endeavored to show that a purely physical cause, to wit, mechanical pressure, is capable of producing a developable impression, thereby answering the objection of the inadequacy of a physical influence to create a basis of development. And, finally, I may remark that although the chemical theory is supported by some distinguished chemists of the present day, I am not aware that there is a single well verified experiment which can be brought forward in support of that view. In the absence of such, I have been necessarily obliged to confine myself to the affirmative side of the question, in support of the existence of a physical image, distinct from chemical reduction, and though often accompanied by it, yet never necessarily."

PHOTOGRAPHY IN NATURAL COLORS.

M. Poitevin has lately succeeded in producing photographs on paper in their natural colors. He prepares his sensitive paper in the following way: Having obtained a layer of violet subchloride of silver on the paper, by the action of light on the white chloride in the presence of a reducing agent, he applies to the surface of the paper a liquid composed of one volume of a saturated solution of bichromate of potash, one volume of a saturated solution of sulphate of copper, and one volume of a solution containing five per cent. of chloride of potassium. This paper is dried and kept in the dark: it will keep good for several days. In this mixture, the bichromate of potash is the principal agent; the sulphate of copper facilitates the action, and the chloride of potassium preserves the whites which are formed. In copying paintings on glass, the exposure to direct light need only last five or six minutes; but the time must, to some extent, depend on the transparency of the picture to be copied, and it is easy to watch the development of the image on the paper. The paper is not sufficiently sensitive for use in the camera. To preserve the pictures, it is only necessary, first, to wash them with water acidulated with chromic acid, then to treat them with water containing bichloride of mercury, afterwards with a solution of nitrate of lead, and, lastly, well wash them with water. After that they will not change in ordinary light, but will, however, turn brown in direct sunlight.—*Quart. Journ. of Science, April*, 1866.

PRINTING PHOTOGRAPHS IN COLORS.

Mr. J. A. Gatty read, on the 4th of October, at a meeting of the Manchester Literary and Philosophical Society, the subjoined paper, describing a process for obtaining colored photographs: —

"My process is based upon the property possessed by ferrocyanide of potassium, of forming clear solutions with certain metallic salts, producing insoluble compounds when the mixture is brought into contact with a deoxidizing agent; the rays of the sun acting as such, a perfect precipitation takes place upon paper or other material prepared with the above-named solution. In producing the specimens sent herewith, I applied to the paper a

concentrated solution, formed of equal parts of ferrocyanide of potassium and nitrate of lead, having found the latter to answer very well, not only as a means of forming a precipitate, but also for assisting in the production of numerous colors. After drying the paper, it was exposed to the sun for about half an hour, and then washed in water in order to dissolve all the unaffected ferrocyanide of potassium and nitrate of lead. I have noticed that the sun acts much quicker when there is a little moisture present. I have, therefore, placed a damp cloth between two or three thicknesses of paper behind the prepared paper. After washing, the photographic image remains behind as a pale greenish precipitate, easily transformed into the various colors, as the following experiments will show: —

"No. 1. (Blue.) Has been steeped in a weak solution of nitrate of iron for about ten minutes, and then washed in water.

"No. 2. (Green.) Same as No. 1, but steeped in a weak solution of bichromate of potash after the nitrate of iron.

"No. 3. (Reddish Brown.) Has been steeped in a solution of nitrate of copper, and then washed.

"No. 4. (Brown.) Has been developed by steeping it in a mixture of weak solution of nitrate of iron and nitrate of copper.

"No. 5. (Dark Brown.) Has also been treated with a solution of nitrate of iron and nitrate of copper, but containing a larger proportion of the former.

"These few experiments will show that a very large number of shades may be obtained by using different salts and mixtures thereof in developing the photograph. A further series of colors may be obtained by destroying the blue with caustic-soda, which, after washing, will leave behind oxides of iron and lead, which may be dyed with vegetable coloring matters.

"All the above experiments were made about four years ago, which goes to prove that the colors are permanent. I hope shortly to be able to resume my experiments, and work the process out more perfectly."

COLORED PICTURES BY PHOTOGRAPHY.

In 1838, Herschel was the first to publish a paper on the various colors which chloride of silver is susceptible of taking under the influence of certain colored rays of light. Mr. Robert Hunt also published, in 1840, a paper referring to the subject; but the most complete series of researches on the subject of the reproduction of the colors of the spectrum, and which led to a process by which several of the colors of the spectrum could be produced on a sensitive surface, is due to Edmund Becquerel. The results arrived at by this gentleman were so remarkable that they drew the attention of the whole scientific world; and the following is an outline of the processes which were applied by him to obtain this interesting result. He took a daguerreotype plate, or a silver-plated one, and having dipped it in a weak solution of chlorine, or, what was still better, a weak solution of hydrochloric acid, by connecting it with the poles of a battery, the brilliant silver surface acquired

different tints, passing gradually from an opaque white to a black tint. He also observed that the tint best suited to obtain favorable results was when the plate had acquired a pearlish pink; and, although he found that the plate so prepared, when placed in the camera obscura, assumed the colors composing the spectrum, still they were faint; but he remedied this defect of intensity of tints by heating for several hours to a temperature of 95° to 100° the chlorinated plate, and then submitting it to the influence of the various colors composing the spectrum. Further, in the course of his studies, he made the important observation that he could replace the peculiar action of heat on his prepared daguerreotype plate, by exposing it to the rays of the sun under a sheet of paper which had been steeped in an acid solution of sulphate of quinine. The effect of this was that the plate of silver assumed an intense white color, nearly resembling that of paper; while if the protective paper had not been used, the silver plate would have gradually acquired a dark tint, and would have lost the whole of its sensitive properties, the protective paper having the power of arresting completely the most refrangible rays of light, especially those which are beyond the line H of the spectrum. Notwithstanding M. Edmund Becquerel's ardent hopes to find a method which would enable him to fix on a sensitive surface the various colors of the spectrum, still he failed; for they faded as soon as they were exposed to the direct rays of light, and could only be preserved in obscurity. But there is one gentleman who deserves great praise for the extraordinary perseverance which he has shown in this class of investigation. I mean the nephew of the discoverer of photography, M. Niépce de Saint Victor. Although I will not enter here into the details of these valuable researches, as they can be found in the "Comptes Rendus de l'Académie des Sciences," still I may just be allowed to state that he has not only by the following process obtained far more brilliant colors than those first produced by M. Becquerel, but has succeeded in reproducing on sensitive plates the various colors of colored surfaces, such as are presented by fabrics, flowers, etc.; and, further, he has lately been so fortunate as to reproduce on his plates yellow and black tints, which had resisted all previous attempts. To give you an idea of the facts arrived at by this gentleman, I may state that he has succeeded in so fixing upon sensitive surfaces the various colors of the spectrum, or of colored surfaces, that they will bear the action of diffused light for several days. In fact, I have seen photographs which reproduce faithfully a small doll dressed up in various colors, and in which even the most minute ornament could be traced; and, what is certainly not less interesting, was the reproduction of the iridescent colors of the peacock's feather. To obtain these marvellous results, M. Niépce de Saint Victor takes a daguerreotype, or silver-coated plate, and dips it into a weak solution of hypochlorite of sodium, having a specific gravity of 1.35, until it has assumed a bright pinkish hue. The plate is then covered with a solution of dextrine, saturated with chloride of lead; it is then dried, and subsequently submitted to the action of heat, as in M.

Becquerel's experiment, or under the screen of sulphate of quinine, also referred to above. The plate is then ready to be placed in the camera obscura, and to receive the colors of the spectrum, or representations of nature, such as flowers, as well as certain colors produced by man. Lastly, he succeeds in increasing the stability of the colors developed on the sensitive surface by covering the plate with an alcoholic solution of gum benzoin; and M. Niépce gives the name of Heliochromy to this branch of photography.

During his lengthened researches, M. Niépce de Saint Victor has made two series of observations, viz., that he can produce with facility, on prepared plates, the binary colors of the spectrum, viz., orange, violet, indigo, and green, if those colors are natural; but, if they are artificially produced by the mixing of two of the primary colors, as red and yellow, or orange and blue, or yellow and blue, he cannot reproduce the binary color, but only one of the two colors employed by the artisan to prepare them. Thus, for example, he can reproduce the natural green of malachite, and the beautiful color known as Scheele's green, but he cannot do so with a mixture of Prussian blue and yellow chromate of lead, the blue only reappearing. These facts enable him to explain why, in ordinary photography, the leaves of plants always appear black, and why, when he attempts to fix on his plates the colors of leaves, they have a bluish hue, the yellow portion of the color not being reproducible.

M. Niépce has made another series of observations which deserve notice, viz., that when a plate, as prepared by his process, is dipped in an alcoholic solution of substances susceptible of imparting a color to flame, such, for example, as strontia, which communicates a red hue to it, or baryta, which gives a yellowish-green color, the prepared plates, when exposed in the camera, will assume the same color as the salt which they have on their surface would impart to the flame of alcohol; and, if a salt of copper be used, which has the property of communicating a variety of tints to the flame of alcohol, the plate also will assume a variety of tints when exposed to the action of light; and during a certain period of his lengthy researches, M. Niépce availed himself of this curious phenomenon to obtain colored plates in the camera.—*Dr. Calvert's Cantor Lectures.*

ARTISTIC COLORING OF PHOTOGRAPHIC PORTRAITS.

So difficult is the task of training a good colorist, that even the accomplished artist feels his inability in endeavoring to impart the information necessary to those he is wont to train in the knowledge whereby he is enabled to produce almost inimitable results.

Without attempting to go deeply into the philosophy of color, analytically or synthetically, it may not be out of place to give, however slight, an idea of how to proceed in coloring a photograph.

It is indispensable that you wash the proof well with a sponge; or, better, as ever at your command, sweep your tongue across it in order to remove any traces of grease or starch.

To color a good, clean print, you must, in the first wash on the face, use as much gum as will bring it nearly, although not quite, to the same gloss as the albumen surface; this wash to be composed of — for a person of ordinary complexion — a combination of rose madder and Indian yellow, or Venetian red alone. With these colors judiciously applied, you can produce any complexion, from the highest glow of health to the most sallow; the shadows to be warm, and in every case glazed even more than the albumen surface. Sepia, neutral tint, burnt umber, chrome yellow, and ivory black, if properly used, will give that life-like brilliancy which is characteristic of health or decay.

Should the photograph be clear and well defined, for draperies and carpets use transparent, but, if the picture be deficient from under-development, use opaque. Of transparent colors for such purposes use the following: crimson lake and burnt sienna, Prussian blue and Indian yellow. Chrome yellow and Prussian blue also make an excellent wash for draperies, although not purely transparent.

For backgrounds, which should ever be made to softly recede from the figure, the following colors may be used with much purpose: cobalt blue, and a little Chinese white, which give a good effect and altogether a pleasing result, vignetting it to your own taste with sepia, or other browns. By way of finish, or to relieve an otherwise poor production, it is sometimes necessary to make what is termed an introduction; that is, a side opening in the background, where a neat landscape may be lightly sketched and colored, comprised of water, land, and sky, or a bit of woodland. These sometimes give a freshness to an otherwise dull picture, or serve to exclude some of those hideous backgrounds so much displayed in *cartes* generally. But, in putting in draperies, carpets, plain or pictorial backgrounds, let them ever be subdued, and in quiet harmony with the figure, the head of which should ever be the principal attraction to the eye. — SCOTT ALEXANDER, *in British Journal of Photography*.

DESTRUCTION OF PHOTOGRAPHS.

A suggestion of considerable value to photographers has been made by Dr. Angus Smith, F.R.S. The cause of the destruction of photographs, apparently by the action of time only, is generally considered to be due in reality to the presence of a minute quantity of hyposulphite of soda remaining in the paper. Hitherto, almost the only plan of getting rid of this agent has been long and continuous washing in cold or hot water. Dr. Smith has suggested oxidizing the hyposulphite of soda into sulphate of soda (which is likely to be harmless), by means of dilute peroxide of hydrogen. This has been little known to chemists, and even now it is seldom obtained in its pure state; it is, however, to be had in solution, and in a state sufficiently strong for many important purposes in analysis. Oxides, such as in the case of manganese, which will not fall till more highly oxidized, are, with advantage, treated by it. The lower oxide may remain unobserved in a solu-

tion, and in a state of minuteness sufficient to keep it in suspension; but, at the moment of contact with the peroxide of hydrogen, it blackens and falls. When the peroxide is poured into a solution of hyposulphite of soda, the change is not observed, as there is no colored oxide to be formed; but when a salt of barium is afterward added, it is found that sulphuric acid has taken the place of hyposulphurous. The strength of the solution does not require to be great: that which is sold contains about nine volumes of available oxygen; if diluted a thousand times, a solution is obtained capable of oxidizing hyposulphites. It appears that all the hyposulphurous acid is instantly converted. Peroxide of hydrogen is in reality an oxide of water: when the oxygen leaves it to do its work, nothing but water is left; nothing being added to be washed out. The peroxide, as sold, contains a little acid (sulphuric); when made alkaline, it does not keep so well. If a drop is put upon a photograph, it very slowly bleaches; its use in this undiluted state is not recommended. Again, if the peroxide, as sold, is neutralized, the bleaching does not take place, at least in an hour, — an ample time. For neutralization, soda may be used. — *Quarterly Journal of Science, July*, 1866.

UNALTERABLE PHOTOGRAPHS.

The only mode hitherto known of producing unalterable photographs has been by vitrification. M. Penabert, however, recently exhibited to the Academy of Sciences some which, though not vitrified, are so indestructible that it is impossible to remove them from the glass, so as to render it capable of being used a second time. The opaline glass employed in the process, having been well cleaned, is to be coated with ordinary collodion that is at least a year old; it is then to be plunged for a few minutes in a sensitizing bath, which contains seven grammes of nitrate of silver to one hundred grammes of distilled water, and sixteen grammes of pure nitric acid to one thousand grammes of the silver solution, and afterward to be exposed for about fifty seconds in the camera. The developing fluid consists of a solution of protosulphate of iron, containing two-thirds more water than that ordinarily used, and one-fifth pyroligneous acid. The positive picture thus obtained is fixed by a weak solution of hyposulphite of soda, and is intensified by a very weak bath of sulphuret of ammonium. — *Intellectual Observer, February*, 1866.

A NEW PHOTOGRAPHIC WASHING APPARATUS.

The majority of cases of photographic fading may be traced to the hyposulphite of soda, which, by so intimately associating itself with the fibres of the paper, is difficult of removal, and which, if not perfectly removed, induces an action by virtue of which the print eventually becomes destroyed. To remove the hyposulphite of soda in the most perfect manner, and in the shortest time possible, is to insure to photographs a longer tenure of existence than they would otherwise have held; and any means by which these requirements can be met are entitled to the greatest consideration.

An instrument, invented and patented by Mr. John E. Grisdale, is capable of washing a full charge of prints in twenty minutes, and that so perfectly, that at the end of this time some ordinary tests for hyposulphite of soda fail to indicate its presence. "My invention," he says, "relates to a peculiar construction and arrangement of centrifugal machinery or apparatus for washing photographic prints, and consists, according to one arrangement, in the employment of a peculiarly-constructed revolving drum in combination with a trough, in which such drum is partially immersed. The prints to be washed are taken from the water in which they have been placed on their removal from the fixing or other bath, and are packed in one or more piles, which piles are placed round the circumference of the drum, each pile being composed of alternate prints and sheets of wire gauze, or other open or reticulated fabric, so that no two prints shall be in contact with each other. These piles are held in their places on the drum by means of open frames or gratings, which bear against the opposite surfaces of each pile, and are secured to the arms of the drum by screws or otherwise, the whole or a portion of such frames or gratings forming a part of the drum itself. Or, according to another arrangement, the piles above described may be laid flat upon a disk, which is made to revolve either vertically or horizontally in a trough or cistern, provision being made in the horizontal arrangement for allowing the piles to be brought in or out of contact with the water as required; or, in lieu of the photographic prints being disposed in the form of piles or packs round a drum or revolving disk, they may be laid separately and individually round the surface of a drum, a webbing of open or reticulated fabric being wound on such drum simultaneously with the placing of the prints thereon, so as to interpose a thickness of the fabric between each succeeding layer of prints. The process of washing consists in alternately driving out the moisture from the prints by the centrifugal action of the revolving drum or disk, and saturating the prints again. During the first part of the process, the prints are not immersed; but when the second part of the process, namely, the saturation, is to be effected, the trough or cistern is to be supplied with water; or the prints may be brought down into the water, and caused to revolve therein and thoroughly saturated, when the water may be run off from the trough again, or the drum or disk elevated, and the moisture expelled by centrifugal force as before."

Freshly-supplied water is forced through every pore of the prints, the consequence being the elimination of every trace of hyposulphite of soda in a very brief space of time. — *British Journal of Photography.*

PHOTO-LITHOGRAPHY WITH HALF-TONE.

The production of printing surfaces on stone, zinc, etc., by the agency of photography, has occupied the attention of experimentalists for many years; and, in many respects, a high degree of success has been obtained. The process of Mr. Osborne, for the working of which a company has recently been formed in Amer-

ica, gives results in line and stipple, which leave little to be desired. Mr. Ramage of Edinburgh, Mr. Lewis of Dublin, Colonel James, and many others, have also attained great excellence in the same direction. Messrs. Simonau and Toovey of Brussels, have attained some success in the production of half-tone; and the attempts of Col. James in the same direction have not been without promise. Still, the fact remains, that no process for the actual production of photographs from nature by means of photo-lithography is in practical working, or has hitherto established a position, and that such a process remains an important desideratum, any means of meeting which would be hailed with a glad welcome by all concerned in the graphic arts.

Unless we are mistaken in our estimate of a series of specimens before us, by Messrs. Bullock Brothers of Leamington, a process which they have recently patented bids fair to meet the long-felt want most successfully, and to render, with a fair amount of delicacy, the true photographic gradation of negatives from nature. The subjects before us, consisting of landscapes with variety of foliage and architecture, are exceedingly excellent, and present all the good points of a good photograph, perfect gradation and half-tone, and great brilliancy, differing little in general effect from good silver prints from the same negatives.

Messrs. Bullock have followed in paths already partially trodden, but have made such practical deviations and modifications as have led them to success where others have only failed. Their aim is to secure in the transfer a suitable grain, so as to obtain the kind of gradation possible in lithography, without producing a coarse or woolly effect. Among the various methods by which they propose to effect this end, the plan used in producing these examples seems to be at once the most practical and efficient. A transfer paper is prepared with a plain solution of gelatin, and when this is dry a grain is printed on it from an aquatint plate. Paper so prepared can be kept in stock, and rendered sensitive when required by immersion in a solution of bichromate of potash. It is then ready for printing and transferring in the usual manner, and produces on the stone a photographic image, the continuous gradation of which is broken up into the stippled gradation of an aquatint plate. This is the broad principle; but it admits of much ingenious modification in practice, which is so far effective that it produces the most successful and promising examples of photo-lithography with half-tone which we have yet seen. — *London Photographic News.*

PHOTOGRAPHY AND THE KALEIDOSCOPE.

About a couple of years ago, a writer in an excellent trans-Atlantic cotemporary, the "Scientific American," remarked: "Let the photographer once combine the kaleidoscope with the camera, and then see with what ease and rapidity he can produce the most charming designs for dress goods, tapestry, oil-cloth, wall-paper, and numerous other purposes. Such a thing is possible." Almost at the same moment that the American writer stated this,

M. l'Abbé Laborde brought under the attention of the French Photographic Society a method which he had adopted to effect the preservation, by photography, of the changeful designs of the kaleidoscope. As a means of preserving patterns for a variety of decorative purposes, this application of photography is deserving of attention; and it may be interesting here to quote from the communication of M. l'Abbé Laborde on the subject. It is worthy of remark, that the method of throwing the designs of the kaleidoscope on a screen by the aid of the magic lantern has since been adopted and exhibited at the Polytechnic Institution: —

"The variety of designs presented by the kaleidoscope, when turned round, is familiarly known to every one; yet we are often surprised at the appearance of very curious and unexpected forms which we see disappear with regret.

"The regular figures which result are depicted on the ground glass of the camera of long focus, and the images are focussed direct without being reflected. This portion is naturally more lighted than the others. It requires several minutes of exposure to obtain a picture on the collodioned plate. We cannot focus the portions of the image which are several times reflected; for they appear in the objective as if they came from greater distance: they lack distinctness, and they also exhibit the defect of planitude in the mirrors.

"Notwithstanding these imperfections, I believe I have attained the aim I proposed to myself, which is, to place before the eyes of those who are occupied with stained glass, paper hangings, and other kinds of ornamentation, very varied patterns, which photography can supply by the hundred." — *Photographic News*.

PHOTOGRAPHIC PRINTING PROCESS FOR PRODUCING COPIES OF BOTANICAL AND OTHER SPECIMENS.

A paper, by Mr. Henry Brightman, was read at a meeting of the Bristol Naturalists' Society, December 7, 1865, proposing a ready method of copying leaves, etc. He says: —

"To lay plants, etc., upon prepared paper, and expose them to sunlight, was a method which had been frequently practiced; but the pictures so obtained were, technically, negatives, the representation of the object being white, on a dark ground. It occurred to the author, that, if these could be rendered transparent, positives might be printed from them. He found, however, that this could be readily done without any previous preparation of the negative; and he exhibited a number of very beautiful photographs, produced in this way, of ferns, leaves, and even a butterfly's wing, showing the wide applicability of the process." Mr. Brightman then described the process in detail; for the negatives, the albumenized paper should be as thin and free from grain as possible, and sensitized by floating on a sixty-grain solution of nitrate of silver. An ordinary printing-frame was used; but a very long exposure was requisite, especially for positives; and this constituted the chief objection to the process, where many

copies were required, as for illustrating a book. The toning bath contained half an ounce of acetate of soda to one pint of water, and one grain of chloride of gold for each sheet toned. The picture was fixed with hyposulphite of soda (eight ounces to the pint), and well washed with water.

Much conversation then took place on this paper, in the course of which Mr. Beattie urged the employment of waxed paper, instead of albumenized, as likely to give a more transparent negative, and spoke of the application of carbon-printing to this process. Mr. Brightman suggested the use of a green instead of a black pigment in that method, to give the natural color of the plant.

PHOTOGRAPHING CANNON BALLS.

Some months ago, when on a visit to Woolwich Arsenal, we were shown by Mr. M'Kinlay, Proof Master, some photographs taken of guns while being fired, which not unnaturally excited feelings of surprise. So rapid had been the exposure, and so well had the proper moment for the exposure been seized, that the projectile could be seen protruding from the cannon's mouth while in the act of proceeding on its distant mission. Mr. M'Kinlay kindly afforded us every requisite information relative to his invention for securing such wonderful results; and, from the fact that the comparative efficiency of certain kinds of small-arms, and the influence they are now exercising in European affairs, are at present receiving a large share of public attention, we think that it may not prove uninteresting to bring before our readers some matters of scientific interest in connection with our own "great guns," and the means employed for ascertaining by photography, and with the utmost possible precision, not only the path of a projectile in the air, but the time occupied in its progress between two or more points anywhere in the course of its flight. It will be obvious that, when it is desired to obtain a photograph of a gun at the moment of discharge, the gun itself must be made subservient to the exposing and covering of the sensitive plate. It is impossible that any person, however delicate his eyes and ears may be, can operate so dexterously as to stop the exposure when the ball has been projected, say a few inches from the muzzle of the gun, and when it is consequently travelling at its greatest velocity. This can only be accomplished by automatic arrangements, aided by electricity.

Let us now suppose that a stereoscopic camera, fitted with powerful lenses of short focus, has a thin, light disk fitted up in front of the lenses, revolving on an axis between the two lenses. Two holes in this disk correspond with the apertures of the lenses, so that if a circular spring — like that of a pair of snuffers — cause the disk to make half a revolution with great rapidity, the holes or apertures will, when flashing past the apertures of the lenses, admit the light for an exceedingly brief period of time. This is the means employed in the arsenal for effecting the exposure of the plate.

We shall now enter into the details of the manner of discharg-

ing and arresting the circular exposing diaphragm. The opening and shutting of the camera at the precise instant of time is, as we have said, by far too nice an operation to be accomplished by hand. It must be borne in mind that a gun commences to recoil as soon as the projectile is fairly clear of its muzzle. The picture which we examined had been taken when the projectile was yet emerging from the gun's mouth, and before it had got quite clear of it, and consequently before the recoil of the gun had commenced. The exposure was very rapid, but not so much so as to show the front edge of the emerging projectile with a sharp outline. Although the gun, from the recoil not having commenced, was quite sharp, the front edge of the projectile was, so to speak, vignetted.

The gun is fired by means of the galvanic tube invented by Mr. M'Kinlay, and such as is used in proving ordnance. Inside of this there is a small platinum wire, which, when a current of electricity is passed through it, instantly becomes red hot, and melts. Let us now see how this affects the operation of photographing the gun. When the gun is ready for firing, the disk in front of the lenses is wound up so that the rotating force of the spring in the centre is at its maximum. It is retained in this position by means of a catch and trigger, the latter of which is operated on by means of an electro-magnet. The following, then, is what takes place: When the galvanic current is sent through the wire, the fine platinum wire imbedded among the gunpowder of the discharging tube or fuse immediately becomes red hot, and melts. But, while in progress of melting, it accomplishes two things; it transmits a current through it by which the electro-magnet becomes vivified and pulls the discharging trigger of the disk in front of the camera lenses; and secondly, it ignites the gunpowder and discharges the gun. But were this all, the exposure would be made before the powder had had time to ignite and consequently discharge the gun; hence it is important that the lenses be kept open until the gun really discharges its contents. The means for effecting this are as simple as they are ingenious and complete. When the trigger acts so as to release the disk from its enforced pent-up condition, it is propelled forward by the central spring until the apertures in the disk and those of the lenses coincide, where, by means of a stop, the disk is retained until the powder is ignited and the gun discharged, when, the platina wire being ruptured, the passage of the electricity is stopped, the electro-magnet simultaneously losing the power by which it was enabled to arrest the rotatory progress of the disk, which thus darts forward and closes up the camera as the contents of the gun are in the act of being ejected from it. — *British Journal of Photography*.

STATISTICS OF PHOTOGRAPHY.

The rapid growth of new and special industries, says the "British Quarterly Review," is a fact so characteristic of the present day, that the statistics of photography can scarcely be regarded as

wonderful, viewed merely as a question of economics. Nevertheless, some of the facts are sufficiently startling. Twenty years ago, one person claimed the sole right to practice photography professionally, in England. According to the census of 1861, the number of persons who entered their names as photographers was 2,534. There is reason, however, to believe that these figures fall short of the real number. Since then it is probable the number has been doubled or trebled, and that, including those collaterally associated with the art, it is even four or five times that number. But these figures fall far short of the number interested in photography as amateurs. We are informed that eight years ago, in establishing a periodical which has since become the leading photographic journal, a large publishing firm sent out twenty-five thousand circulars — not sown broadcast, but specially addressed to persons known to be interested in the new art-science. The number of professional photographers in the United States is said to be over fifteen thousand, and a proportionate number may with propriety be estimated as spread over continental Europe and other parts of the civilized globe.

But a more curious estimate of the ramifications of this industry may be formed by a glance at the consumption of some of the materials employed. A single firm in London consumes, on an average, the whites of two thousand eggs daily in the manufacture of albumenized paper for photographic printing, amounting to six hundred thousand annually. As it may fairly be assumed that this is but a tenth of the total amount consumed in this country, we obtain an average of six millions of inchoate fowls sacrificed annually, in this new worship of the sun, in the United Kingdom alone. When to this is added the far larger consumption of Europe and America, which we do not attempt to put in figures, the imagination is startled by the enormous total inevitably presented for its realization.

In the absence of exact data, we hesitate to estimate the consumption of the precious metals, the mountains of silver and monuments of gold, which follow as matters of necessity. A calculation, based on facts, enables us to state, however, that for every twenty thousand eggs employed, nearly one hundred weight of nitrate of silver is consumed. We arrive thus at an estimate of three hundred hundred weight of nitrate of silver annually used in this country alone in the production of photographs. To descend to individual facts more easily grasped, we learn that the consumption of materials in the photographs of the International Exhibition of 1862, produced by Mr. England for the London Stereoscopic Company, amounted to twenty-four ounces of nitrate of silver, nearly fifty-four ounces of terchloride of gold, two hundred gallons of albumen, amounting to the whites of thirty-two thousand eggs, and seventy reams of paper; the issue of pictures approaching to nearly a million, the number of stereoscopic prints amounting to nearly eight hundred thousand copies. — *Scientific American.*

ANILINE PROCESS OF PHOTOGRAPHIC PRINTING.

Mr. W. Willis of Birmingham has recently laid before the Photographic Society an account of his aniline process of photographic printing. It consists of a new method of developing the pictures produced by Hunt's chromatype process, in which the paper is prepared with a solution of bichromate of potash and sulphate of copper. The difficulty of finding a suitable developer for the prints so obtained has hitherto prevented the use of this method. The employment of nitrate of silver or mercury, besides being attended with some practical inconveniences, produces pictures of a red color, which, although suitable for the reproduction of the red chalk sketches of the old masters, is inadmissible for ordinary drawings. According to Mr. Willis's process, the paper is sensitized with a solution of bichromate of potash or ammonia, containing a small quantity of sulphuric or phosphoric acid, and, when dry, is exposed to light under a positive photograph or drawing. It is then placed over a solution of aniline in benzole, turpentine, or ether, preferably the former. The parts forming the picture — *i. e.*, those not acted upon by the light — are developed of a mauve color, which is very permanent, not being changed in tint by the application of acids or alkalies. The process has already been introduced in Birmingham for the multiplication of engineers' drawings, in cases where the number required is not sufficiently great to admit of lithography being used with advantage. The property possessed by bichromate of potash of forming a black compound with a solution of logwood, which has been used for the manufacture of cheap writing-ink, has also been applied by Mr. Fox of Edinburgh to the development of these chromatype pictures. Both these processes have been secured by patent.

A new solvent for the greater part of the aniline colors has been discovered by M. G. de Claubry, and communicated by him in a paper to the French Academy of Sciences. In place of alcohol and methylated spirit, which are high-priced or injurious to the workmen, M. de Claubry proposes to substitute a decoction of Panama bark (*Quillaria*), or of Egyptian soap-wort (*Gypsophila*). Solutions of the coloring products can be easily obtained by pouring the boiling decoction upon the powder; after stirring and decanting the solution, the operation must be repeated, if any part of the powder remain undissolved. It was found that the red colors dissolved most readily, and the blues less so. If, therefore, the coloring matter be purple, it is necessary at the end to mix the different solutions together in order to obtain a dye of the right tint.

IMPROVEMENTS IN PHOTOGRAPHY.

Photosculpture. — A process is now in use in London by which busts, statuette likenesses, etc., may be produced in clay or plaster at a small cost, by the aid of photography. The operation is as follows: Eight photographs are taken of the sitter from eight

sides; from each of these, profiles are cut out in thin sheet metal; each pair of profiles is caused to plane away the sides of a block of clay corresponding to the position in which their photograph was taken. Thus, the clay comes to have on each side the same profile as that of the sitter, and is thus a likeness requiring but a few touches from the artist to give it finish and exactness.

The "carbon printing" photographic process has been applied to the permanent ornamentation of porcelain with success; any material fit for burning into that substance being substituted for the carbon or India ink of the original operation. — *Franklin Journal, January*, 1866.

Photographs of the Moon. — Mr. Warren De la Rue has obtained, with his thirteen-inch telescope, photographs of the moon so perfect that they bear being enlarged to a diameter of three feet; and they are found so exact, when submitted to micrometrical examination, that they furnish correct data for the measurement of the vibrations of the moon. They also serve as a foundation for the lunar map, six feet in diameter, undertaken under the auspices of the British Association.

New Artificial Light for Photography. —Mr. Sayers of Paris obtains a light almost equal in power to that of magnesium, and much cheaper, from the combustion of a mixture of twenty-four parts of well-dried and powdered nitrate of potash with seven of flowers of sulphur and six of red sulphuret of arsenic. The mixture costs only twelve cents a kilogram. — *Les Mondes, Jan.* 4, 1866.

Light for Photographic Purposes. — A substitute for the yellow glass, used by photographers to intercept actinic rays, has been suggested by W. Sidney Gibbons of Melbourne. This is a mixture of gelatin and bichromate of potash, spread as a varnish over their cotton cloth or similar material.

In preparing a window for the illumination of a photographer's dark room, Obçrnetter mixes an acid solution of sulphate of quinine with some gum or dextrine, and paints the mixture over a thin sheet of white paper. With this he covers the window panes, and he states that, on the brightest day, a window so prepared will allow no actinic light to pass.

Varnish for Photographs. —M. Bussi first brushes the prints over with a solution of gum arabic, and, when this is dry, applies a coating of collodion. The following are the proportions recommended: —

1. Clear transparent gum arabic, 25 grammes; distilled water, 100 cub. cents.; dissolve and strain.

2. Gun-cotton, 3 grammes; alcohol, 60 grammes; ether, 50 grammes.

By this double varnish the inventor insures the preservation of proofs. — *Chemical News.*

Magic Photographs. —The familiar experiments of the laboratory have in the present day a great tendency to become the magic of the drawing-room. Magic photographs are among the most recent of the scientific toys which take the public attention. These are of various kinds. The first and most common mode of producing them consists in placing an apparently common

piece of blotting-paper upon an apparently plain piece of white albumenized paper, moistening the two, and producing at once a photographic picture. The explanation of this is simple, and is doubtless familiar to old photographic experimentalists; we practiced the same feat a dozen years ago. It consists in bleaching, until it is white and invisible, by means of bichloride of mercury, a silver print; then, taking a piece of blotting-paper which has been previously immersed in a solution of hyposulphite of soda, and placing it in contact with the immersed print; this, when moistened, at once darkens the bleached image, and a picture, consisting chiefly of sulphide of mercury, is produced. We have received some examples from Mr. Swan, and details will be found in Dr. Vogel's German letter in this number. We have just received from Mr. Hughes's establishment a still prettier application of parlor magic, in which, by placing an apparently blank piece of paper in a solution — the material for which is inclosed in the packet — a beautiful blue print is produced. This is doubtless the result of one of the applications of the Cyanotype process of Sir J. Herschell, which may be made to produce many beautiful transformations. — *Photographic News.*

The Magic Photograph is selling in Paris and London, in two envelopes, one containing pieces of white albumenized paper; the other, slips of white blotting-paper of a corresponding size. One of the former is moistened with water, and a piece of paper from the other envelope, likewise wetted, is laid thereon, when a beautiful photograph is immediately developed on its albumenized surface. Photographs have, of course, been printed in the usual manner on the albumenized slips, and then decolorized with bromic or iodic acid, or some such agent; the other pieces of paper have been soaked in hyposulphite of soda, and the application of this reducing agent to the hidden photograph instantly brings it again to view.

SUBMARINE PHOTOGRAPHY.

A French artist, M. Bazin, has been experimenting lately, with the design of obtaining photographs of sunken vessels, so that, in attempting to raise the same, positive knowledge can be had of their relative positions. To accomplish this, M. Bazin descends to the necessary depth, in a strong sheet-iron box, which he calls his "photographic chamber." Thick glass windows afford every facility for making the necessary preliminary observations, and the picture is taken by the aid of a strong electrical light.

An unpleasant feature of the apparatus is, that the operator is absolutely hermetically sealed, for no means are provided for supplying air, the chamber being constructed of a proper size to contain the quantity required during the ten or twelve minutes occupied in obtaining a negative.

SUBTERRANEAN PHOTOGRAPHY.

A firm in Cincinnati have obtained the exclusive right of taking views in the Mammoth Cave of Kentucky for five years. The process successfully used in taking pictures of the interior of the Great Pyramid is adopted, using the magnesium light. The dampness of the cave, the smoke arising in the consumption of large quantities of magnesium, the divergency of the artificial light, and the magnitude and proximity of the objects to be photographed, present a number of serious difficulties. Powerful reflectors are used to throw a flood of light upon the object, and the plate is allowed about twice the exposure required by the light of the sun.

PHOTOGRAPHING UPON SILK.

A process has been devised at Lyons, France, for photographing upon silk, linen, etc., so that persons instead of marking their initials upon the corner of a handkerchief, can have their photographs taken upon the fabric. In the silk shops, various articles are exhibited, photographed with names, portraits, and fanciful devices. The pictures are not injured by washing, and the process is said to be easily and rapidly effected.

PHOTO-MICOGRAPHY.

Dr. J. J. Woodward, U. S. A., in a paper communicated to "Silliman's Journal," for September, 1866, on the subject of photography of microscopic objects, gives the following as the principles involved: 1. To use objectives so corrected as to bring the actinic ray to a focus. 2. To illuminate by direct sunlight passed through a solution of ammonio-sulphate of copper, which excludes practically all but the actinic extremity of the spectrum. 3. Where it is desired to increase the power of any objective, to use a properly constructed achromatic concave, instead of an eye-piece. 4. To focus on plate glass with a focussing glass instead of ground glass. 5. With high powers, to use a heliostat to preserve steady illumination. 6. Where an object exhibits interference phenomena when illuminated with parallel rays, as is the case with certain diatoms, and many of the soft tissues, to produce a proper diffusion of the rays by interposition of one or more plates of ground glass in the illuminating pencil. Strict adherence to these principles is indispensable to success. The most powerful objective with which photographs have been taken for the Army Medical Museum, was 1-50, made by Messrs. Powell and Lealand of London. The subject selected for the experiment was *Pleurosigma angulatum;* with 1-50, and 3¾ feet distance, and without an eye-piece, a picture of a portion of a frustule was obtained, magnified 2.344 diameters; this negative readily bore enlargement to 19.050 diameters; the field in the picture is 6 inches in diameter, and is remarkably sharp in the centre, but shows considerable curvature, and on the edges is quite out of

focus. These photographs confirm the opinion of Mr. Wenham and Prof. Rood, as to the circular nature of the markings on *P. angulatum*. It is remarkable that the markings appear hexagonal in both the small pictures, if viewed with the eye at the visual distance; while on close inspection, or with a lens, they are seen to be circular in the pictures; with 19.050 diameters, the circular shape of the markings is very plain, but, if viewed from a considerable distance or with a concave lens, they appear hexagonal.

NEW ILLUMINATORS FOR OPAQUE OBJECTS.

H. L. Smith, of Kenyon College, contributes a paper on this subject to "Sillimans' Journal," for September, 1865, from which the following are extracts:—

"In attempting to study the structure of the diatomaceous frustule, I found it impossible to view it with high powers as an opaque object by any means hitherto devised. In a valuable paper on the scales of the podura ('Mic. Jour.,' N. S., vol. 2, p. 86), Mr. Richard Beck has stated that there is no difficulty in viewing them as an opaque object, with the one-eighth-inch objective and condensers rightly placed. Any illumination of diatoms thus obtained is almost useless, from the great obliquity of the light, and, with powers higher than the one-eighth-inch, is quite impossible. Mr. Ross's ingenious arrangement, suggested by Mr. Brooke, of a plain reflector, flush with the front surface of the objective and receiving light from a truncated ellipsoidal reflector below, is so exceedingly difficult to use, and only with a special mounting of the object, that it has never been generally adopted. Mr. Wenham's method is entirely inapplicable to diatoms, inasmuch as it depends upon the total reflection of the light from the under surface of the glass cover of a mounted object, and in such case the diatoms, from their transparency, and the near coincidence of refractive index of silex with that of the mounting fluid, throw back but a feeble light, and are nearly invisible. The use of the well-known collimating eye-piece suggested to me the idea of making the objective its own condenser; and upon communicating this idea to Mr. Wales, already well known for the excellence of his objectives, he at once sent me a trial instrument. This first illuminator proved so far successful that I was induced to persevere; and, with his assistance, an 'illuminator' has been constructed which gives entire satisfaction, and answers admirably with all objectives from four-tenths to one-fiftieth.

"It must be borne in mind that there are certain difficulties to be overcome in this mode of illumination, the chief of which is the reflection of the light from the posterior surface of the back combination of the objective. All the difficulties are now surmounted, and there is no trouble in viewing diatoms, or other objects, mounted dry, and uncovered, with the highest powers of the microscope, and with abundant illumination; and this without any trouble in mounting the object on little disks or pins, but using the ordinary three-inch by one-inch slide.

"As I do not intend here describing the instrument in detail, I will only say that it consists essentially of a rectangular brass box, having the 'society screw' at the top, to attach it to any microscope tube, and at the bottom, to receive any objective; and so constructed that it can be placed in any position with regard to the light. A brass draw, moved by screw and milled head, slides into the box, and carries a reflector of silver, also movable on its own axis by means of small milled heads: the forward edge of the reflector is curved, and it is concave, having a focus of about six inches. By means of the screw, the curved edge of this reflector can, when adjusted at an angle near forty-five degrees, be pushed more or less over the opening at the back of the objective. Opposite to the reflector, and attached to one side of the box, is a revolving circle of diaphragms, of great use in regulating the light, so as to exclude all fog or glare; the apertures vary from three-twentieths to one-twentieth of an inch.

"As the 'illuminator' is already in the hands of many, I append a few simple directions as to its use. The objective must be adjusted for an uncovered object, though I find few are rightly marked. An ordinary paper-covered slide, with bits of gold leaf on it, answers admirably as an object to adjust the light. The illuminator being screwed on to the tube, and the circle of diaphragms placed facing the light (I find the ordinary coal-oil lamp with flat flame to answer admirably, the flat side being toward the reflector), turn the reflector at an angle of about forty-five degrees, and allow the light to enter the largest aperture of the diaphragm. By means of the screw, push the reflector forward nearly as far as it will go. Turn the reflector on the axis of the tube and on its own axis, until the light, which may be placed ten or twelve inches to the left of the microscope, and directly opposite the circle of diaphragms, is reflected down on the paper-covered slide, the tube of the microscope being racked up to about the position it will occupy when the objective is screwed on and in focus. The light thus reflected down should appear just at the curved edge of the reflector, in the axis of the tube, when looking through the tube, the eye-piece being removed. Now screw on the objective, and, before replacing the eye-piece, bring it into focus. The field will appear brilliantly illuminated, as in using a lens with a Lieberkuhn; if not, a slight movement of the reflector, or diaphragm, or light, will quickly accomplish this. Put in the eye-piece and adjust for focus; if the field is not clearly illuminated, say with one-fifth-inch objective, a little fingering of the reflector, or diaphragm, will suffice to effect this. The screw which moves the draw and reflector may now be withdrawn, uncovering all but about a quarter or one-half of one side of the posterior lens of the objective; and, if care has been taken to properly adjust the diaphragm and reflector, a most brilliantly illuminated field, free from all fog and glare, will reveal objects with a beauty and clearness inconceivable by those who have never used high powers of the microscope upon opaque objects. The most common objects appear with new and hitherto unexpected beauty, brilliant not only with their own proper colors, but reflecting iridescent tints from their membranes.

The diatoms are especially beautiful; and no one can view, without a sense of profound reverence and unspeakable emotion, the elegant structure of Arachnoidiscus and Heliopelta; of Surirella and Pinnularia.

"On thus accomplishing the illumination of opaque objects under the highest powers of the microscope, a powerful aid to investigation is furnished, which, I doubt not, will be rightly appreciated.

"An inexperienced microscopist may find some difficulty at first, but a few trials will ensure success; and, when properly used, there is no want of light with the one-twelfth or even one-sixteenth with the B or C eye-piece."

Mr. Charles Stodder exhibited before the Massachusetts Institute of Technology, in December, 1866, a new illuminator of opaque microscopic objects under high powers, the objective being its own condenser, — the invention of Mr. Tolles.

The principal difficulty met with in passing a beam of light down through the objective of a microscope, and thus condensing a strong light upon an opaque object is, in the case of high powers especially, the reflection back of a considerable portion by the lenses of the objective. This causes fog and obscuration of the image, though the object be well illuminated. This reflection takes place principally at the interior front surface of the front system.

To obviate this difficulty, a small rectangular prism, immediately above the front system, is so far introduced into the side of the objective mounting as to slightly encroach upon the extreme margin of the upper surface of the combination. When parallel rays are reflected by this prism down through the marginal parts of the front covered by it, they will have their focus much beyond the place of the object. As a medium case, their distance of convergence would be ten times the focal distance of the objective; consequently, a much greater portion of the whole light incident upon the front system would be transmitted, and whatever amount experienced reflection would be dissipated by travelling back through the objective in a path widely different from that of the visual pencil.

Mr. Stodder also exhibited a small telescope, of seven-tenths of an inch aperture, and magnifying thirteen diameters, equal to any instrument of two-inch aperture and three or four feet long, with which he had been able to compare it. With this instrument, which can be carried in the waistcoat pocket, he had been able to distinguish the satellites of Jupiter, and similar astronomic objects. This was also made by Mr. Tolles; and, if his present plans succeed, the cost of telescopes of large size will be diminished one-half by the great reduction in the size of the lenses.

FOUCAULT'S SHEATHED OBJECTIVES FOR THE TELESCOPE.

The concentration of the luminous rays of light at the focus of the telescope, when the sun is the object to be observed, renders observations very difficult and sometimes even dangerous. M. Leon Foucault has conceived the idea of utilizing the property

which certain metals possess of arresting the calorific rays, while they allow the luminous rays to pass through. Silver, when deposited by a particular chemical process in very thin layers, possesses this property in a high degree. M. Foucault has sheathed the objective of a telescope with a layer of this metal, and there is produced at the focus of the instrument an image perfectly clear and agreeable to the eye. It exactly resembles one which a violet-colored glass would produce.

This discovery of M. Foucault has been pronounced by M. Le Verrier to be of the highest possible importance. M. Foucault's experiment was made upon a telescope with a very small objective. Since then, further experiments have been made on one of nine inches, which were quite satisfactory. The solar rays refracted by the objective sheathed with the metal have a very peculiar bluish tint, which made M. Wolff imagine that a considerable proportion of the calorific rays might possibly have been eliminated. The rays were examined with a spectroscope, and were found to be deprived of their extra redness, and inclined to be of a very deep blue color. Clearly, the calorific rays had been stopped in their passage. Theory thus afforded the most brilliant confirmation of experience.

A large objective at the Observatory of Paris, which was in process of construction, afforded an excellent opportunity for experiment. The exterior surface of the glass was duly silvered, and, on turning towards the sun, the image was presented devoid almost entirely of its heat. The layer of silver in no way interfered with the optical properties of the glass. All the numerous details which the most experienced observers have detected in sun-spots were at once visible. "The entire surface of the sun appeared covered with an irregular stippling, the constituents of which were of different sizes, and grouped in constellations of various forms." "In proportion," says M. Le Verrier, "as we see the image better, all idea of a regular structure vanishes; nor is there any indication of such a one as would result from the agglomeration of identical elements placed in juxtaposition or dovetailed with each other. At some moments, the clearness is such as to promise the analysis of the shaded portions, and make us long to have recourse to more and more powerful instruments." M. Flammarion, however, admits that the medium does throw some kind of veil over the object investigated.—*Reader.*

TEMPERATURE AT GREAT ELEVATIONS.

Mr. Glaisher has given, in a lecture at the Royal Institution, a *resumé* of his scientific experiments in balloons. Tables, recording the decline of temperature with elevation, show that when the sky was clear, a more rapid decline took place than when the sky was cloudy. Under a clear sky, a fall of 1° takes place within 100 feet of the earth; but at heights exceeding 25,000 feet, it is necessary to pass through 1,000 feet of vertical height to obtain a fall of 1° in temperature. At extreme elevations, in both states of the sky, the air became very dry, but, as far as his experiments went,

was never quite free from water. From ascents made before and after sunset, Mr. Glaisher concludes that the laws which hold good by day do not hold good by night; indeed, it seemed probable that at night, for some little distance, the temperature may increase with elevation instead of decreasing. From experiments made on solar radiation with a blackened bulb thermometer, and with Herschel's actinometer, it was inferred that the heat-rays from the sun pass through space without loss, and become effective in proportion to the density or the amount of water present in the atmosphere through which they pass. If this be so, the proportion of heat received at Mercury, Venus, Jupiter, and Saturn, may be the same as that received at the earth, if the constituents of their atmospheres be the same as that of the earth, and greater if the amount of aqueous vapor be greater; so that the effective solar heat at Jupiter and Saturn may be greater than at either the inferior planets, Mercury or Venus, notwithstanding their far greater distances from the snn. This conclusion is most important, as corroborating Professor Tyndall's experiments on aqueous vapor. Experiments on the wind showed that the velocity of the air at the earth's surface was very much less than at a high elevation. A comparison of the temperature of the dew point, as shown by different instruments, gave results proving that the temperature of the dew point, as found by the use of the dry and wet bulb thermometers, and Daniell's hygrometer, is worthy of full confidence as far as the experiments went. —*Reader.*

THE EFFECT OF SUNSHINE ON FIRE.

At the meeting of the Scientific Association at Buffalo, Prof. Horsford, of Cambridge, read a very interesting paper on the above subject.

He commenced by alluding to the popular notion that sunshine deadens fires; mentioning that the fires in grates, in rooms having southern exposures, burn briskly in the early part of the day, slacken before noon, and revive again before sunset. Stoves and ranges, that bake well in the autumn, winter, and spring, fulfil their office but indifferently in the height of summer. Some furnaces, in which iron is generally smelted without difficulty, cannot, in very hot terms, be brought to a working heat. While the popular mind ascribes these effects to some agency of the sun, scientific men are disposed to regard the effects as rather apparent than real.

The first recorded research bearing upon the subject was made as long ago as 1825, by Dr. Thomas McKeever, who found, as he conceived, the popular impression sustained. In his experiments, a given weight of wax taper was consumed quicker in the dark than when exposed to the sun. A given length of candle required less time for combustion in the dark than in sunshine. A given weight burned quicker in a painted lantern than in an uncoated lantern, both alike exposed to the sun.

These experiments did not find acceptance with Gmelin, and did not appear in the original "Handbook of Chemistry," doubt-

less from a conviction that some error must have occurred either in the method or record of observation. Nevertheless, Dr. McKeever's experiments appear as additions in the Cavendish Society's translation of the Handbook. The summary of his results may be stated thus: It required eleven minutes to burn in the sunshine the same weight of candle that burned in the dark in ten minutes.

Similar experiments were made at a later period by Dr. Morrill Wyman of Cambridge, and reported to the American Academy of Arts and Sciences. Ths result at which he arrived was exactly the reverse of that reached by Dr. McKeever. He burned two sperm candles, each alternately for half an hour in the sunshine and darkness, and found the candle, during its exposure to sunshine, burned more rapidly than when in the dark.

In 1856, the subject was taken up by Prof. Joseph Le Conte of Columbia, S. C. He concentrated, with the aid of a reflector and burning glass, the sun's rays upon the flame only of a wax (sperm) candle in a large, dark room. At the same time another candle was burning in the same room, under identical circumstances, except that the flame was not exposed to the sun's rays. The result showed that the effect of the sun's rays, though greatly exaggerated by concentration, when confined to the flame, did not appreciably increase the consumption of tallow.

Here, then, we have, apparently, all possible results of experiment, to wit: Sunshine diminishing the rate of combustion, as observed by Dr. McKeever; augmenting the rate, as observed by Dr. Wyman, and producing upon it no effect whatever, as shown by Prof. Le Conte.

Dr. McKeever ascribed the retardation to some peculiar effect, as of interference,of the solar rays upon flame.

Dr. Wyman inferred that the sunshine, by warming the tallow of the candle exposed to it, facilitated its melting, and by so much spared, for destructive distillation and combustion, the heat of the flame, which would have otherwise, in larger measure, gone to liquefy the tallow.

Le Conte conclusively showed that, when the column of wax or tallow is sheltered, and the sunshine directed solely on the flame, the effect on the consumption of the tallow is too small to be recognized.

The observations of the latter experimenters agree in throwing doubt upon the interpretation Dr. McKeever gives of his own experiments.

Prof. Horsford ascribes the source of error in Dr. McKeever's investigation to the incidental greater flaring of the candle in the dark. The experiments with the lantern he explained by the well-known effect of dark paint in absorbing radiant heat, and converting it into heat of conduction, by which the air in the painted-glass lantern was more heated than in the lantern not painted.

Prof. Horsford then gave an account of the diminished draft in the range flue of his dwelling-house during the recent hot term, which rendered it impossible to bake meats or bread in the oven

of his range. This continued from eleven o'clock to about three, within which hours bread could not be baked. With the decline of the sun in the afternoon, as in the early morning, the oven performed its office better. The chimney was fifty-four feet high; the roof of the house was of dark slate, and it was all exposed to heat before eleven; some of it began to pass into shade about three.

In the effect of this greater exposure to the sun during the hours when the sun is brightest, Prof. Horsford found the explanation of the observed phenomenon. The heated top and sides of the house warmed the air in contact, giving rise to an upmoving column from the top of the house and to an endless shroud of air sweeping up the sides of the house. This ascending shroud draws the air from the cracks, doors, and windows of the house, lessening the pressure of the air in the interior, and, of course, diminishing the draft.

The following are his conclusions: —

1. That sunshine, falling on the flame only of a burning body, does not affect its rate of combustion. 2. That, other things being equal, neither light nor darkness exerts appreciable influence on the rate of combustion. 3. That, other things being equal, of two samples of the same combustible, one burning in sunshine will consume more rapidly than one burning in darkness. 4. That combustion during the winter is more vigorous than in summer, because a given volume of air contains more oxygen, is denser and dryer. 5. That slight currents, by causing a flame to flare and come in contact with more air in a given time, cause more rapid combustion; and, by presenting greater surface from which radiant heat issues to warm the combustible about to burned, increase the rate of combustion. 6. That the diminished draft of chimneys in very hot weather, when the general atmosphere is at rest, and the sunshine intense, is due to upward currents on the outside of the house, arising from the heated surfaces of the roof and walls, which currents draw outward through cracks, and open doors and windows, the air from the interior of the house, and so lessen the pressure within, and overcome the draft of the chimney. 7. That the popular impression that intense sunshine lessens the draft of chimneys is founded in fact. — *Scientific American.*

TRANSFORMATION OF MOTION INTO HEAT.

Mr. Rennie has demonstrated in the most satisfactory manner that this transformation takes place, even in the case of fluids. He boiled an egg in six minutes by merely placing it in a vessel which contained about ten pounds of water, and which was made to revolve two hundred and thirty-two times in a minute. In this case, motion was the only possible source of heat; and the result was the more striking, as the friction of fluids is so very much less than that of solids. — *Intellectual Observer, May,* 1866.

DURATION OF THE SUN'S HEAT.

Professor Thomson assigns to the sun's heat, supposing it to be maintained by the appulse of masses of matter, a limit of 300,000 years; and to the period of cooling of the earth, from universal fusion to its actual state, 98,000,000 years. These are the lowest estimates sanctioned by any mathematician.

DIFFERENTIAL RHEOMETER.

In a note, on the employment of a double-wire rheometer in experiments on radiant heat, sent to the Academy of Sciences by M. P. Desains, the author states that he employs a kind of differential apparatus essentially composed of a single source of heat, of two piles, of a double-wire rheometer, and finally of a rheostat. The apparatus is so arranged that the equilibrium, once obtained, remains uniform however the heat from the source varies; but if the smallest variation takes place in one of the radiations, the needle quits the zero point. M. Desains has applied this apparatus to the examination of the absorption of heat by transparent gases, and finds that it gives very delicate and certain indications. — *Scientific American.*

CONDUCTING POWER OF MERCURY.

M. Gripon has presented a note to the Academy of Sciences on the conducting power of mercury for heat. Experiments made after Peclet's method showed that, if the conducting power of silver equals 100, that of mercury equals 3.54. It stands, therefore, the last of the metals, and a little before marble and gas coke. The author mentions that, in this case, the conducting power for heat and for electricity are very different, the former being 3.54, the latter 1.80. — *Mechanics' Magazine.*

A NEW PYROMETER.

Messrs. St. Claire Deville and Trooste have invented a pyrometer capable of measuring a temperature reaching as high as 1530° C. At this heat, the inventors state, copper and silver are vaporized, and feldspar perfectly fused.

IMPROVEMENT OF THE HYPSOMETER.

The boiling points of fluids depend on the pressure of the air; the greater the altitude of any place above the ordinary level of the earth's surface, the lower the boiling point of a given fluid, because the less the barometric pressure in that place; and hence the height of any place may be found by means of the boiling point of water in that place. With this object, a peculiar kind of thermometer, termed a hypsometer, or, more correctly, a hypsothermometer, has been constructed. It is marked not with degrees of temperature, but with barometric pressure corresponding to these

degrees, or, better still, according to the latest improvements of M. Abaddie, with the altitudes corresponding to the temperatures, supposing them to be the boiling points of water. The hypsometer is, for several reasons, more suitable for the purposes of travellers than the barometer: it is more easily carried, and less easily injured, and it requires, not an observation, but an experiment which is made with greater facility, and is less subject to error. — *Intellectual Observer, October*, 1866.

THERMO-ELECTRIC ELEMENTS OF GREAT MOTIVE POWER.

Stefan has examined a variety of mineral substances, with relation to their thermo-electric power at high temperatures. The mineral to be examined was placed upon one end of a strip of copper, while the end of a copper wire rested upon the mineral, the whole being pressed together to insure contact. The wire and copper strip were connected with a galvanometer of great resistance, and the copper strip was then heated by a spirit lamp. In examining the mutual relations of the minerals, a copper strip was placed between them, wires attached to the free ends of the fragments of mineral, and the whole pressed together by a wooden press. The free end of the copper strip was then heated, and the heat conducted to the minerals. In the following enumeration of the elements employed, the positive element is always placed first; and the number appended signifies how many of the elements give an electro-motive force equal to Daniell's cell: —

1. Foliated copper pyrites — copper; 26.
2. Compact copper pyrites — copper; 9.
3. Pyrolusite — copper; 13.
4. Compact copper pyrites — foliated copper pyrites; 14.
5. Copper — crystallized cobalt pyrites; 26.
6. Granular cobalt pyrites — copper; 78.
7. Copper — iron pyrites; 15.7.
8. Compact copper pyrites — iron pyrites; 6.
9. Foliated copper pyrites — iron pyrites; 9.8.
10. Copper — erubescite; 14.
11. Fine bleischweif — copper; 9.8.
12. Coarse bleischweif — copper; 9.
13. Galena in large crystals — copper; 9.8.
14. Bleischweif — erubescite; 5.5.

The great influence of structure upon the thermo-electric relations is seen in Nos. 1, 2, and 4, and still more in 5 and 6. A mass of cubical crystals of galena was at some points negative, at others positive, to copper. The densest, No. 14, has the greatest electro-motive force yet observed in thermo-electric series; but the substances employed are all bad conductors. The author considers, and we think justly, the above results as of great importance for the physics of the earth, and proposes to continue the subject. In a note to Stefan's paper, Poggendorff calls attention to an observation of Marbach, made in 1857, according to which, crystals of iron pyrites ($Fe. S_2$) and of cobaltine ($Co. S_2 — Co. As_2$), which cannot be distinguished, either in crystalline form or in

composition, are divided, so far as their thermo-electric relations are concerned, into two groups. Calling the two forms of the minerals *a* and *b*, Marbach gives the following series, reckoning from negative to positive: Iron pyrites, *a*; cobaltine, *a*; bismuth, German silver, platinum, lead, copper, brass, silver, cadmium, iron, antimony cobaltine, *b*; iron pyrites, *b*. — *Pogg. Ann., April*, 1865, *as quoted in American Journal of Science, September*, 1865.

A NEW AND POWERFUL THERMO-ELECTRIC BATTERY.

In a communication to the Vienna Academy, dated March 16, 1865, S. Marcus described a new thermo-electric battery, which possesses extraordinary interest, both in a theoretical and practical point of view. The properties of the new battery are as follows: —

1. The electro-motive force of one of the new elements is equal to 1-25th of that of a Bunsen's element of zinc and carbon, and by its internal resistance is equal to 0.4 of a meter of normal wire. 2. Six such elements are sufficient to decompose acidulated water. 3. A battery of 125 elements evolved in 1 minute 25 cubic centimetres of mixed oxygen and hydrogen, although decomposition took place under disadvantageous circumstances, as the internal resistance of the battery was much greater than that of the voltameter in the circuit. 4. A platinum wire of ½ millimeter in thickness, introduced into the circuit, melted. 5. Thirty elements develop in an electro-magnet a lifting power of 150 pounds. 6. The current is generated by warming only one of the contact sides of the elements, and cooling the other, by means of water of the ordinary temperature.

As positive metal in these batteries, Marcus employs an alloy of 10 parts of copper, 6 of zinc, and 6 of nickel. The addition of 1 part of cobalt increases the electro-motive force. For the negative metal he uses an alloy of 12 parts of antimony, 5 of zinc, and 1 of bismuth. The electro-motive force of the alloy is increased by repeated fusion. In place of these alloys, a particular kind of German silver, known as alpacca, may be used with the same negative metal; or, as the positive metal, an alloy of 65 parts of copper and 31 of zinc, and, as the negative metal, an alloy of 12 parts of antimony and 5 parts of zinc. The bars are not soldered but screwed together. The mechanical arrangement is such that only the positive metal is directly heated, the negative metal being warmed by conduction; the former melts at about 1200° C., the latter at about 600° C.

An interesting fact in relation to the transformation of heat into electricity in the thermo-electric battery, is, that the water which serves to cool one of the contact sides of each element, becomes very slowly warmer so long as the circuit remains closed, but is heated pretty rapidly when the circuit is open. The alloys employed in this battery fulfil several conditions essential to the production of powerful electrical currents by heat. These conditions are, that the metals employed should be as far as possible from each other in the thermo-electric series; that they should permit

great differences of temperature, so as to avoid the necessity of using ice; that they should not be expensive; and that the insulating material should resist a high temperature, and possess sufficient solidity and elasticity. The thermo-electric battery in question was constructed in reference to the use of a gas flame. The single element consists of bars of unequal dimensions, the positive bar being $7''$ long, $7'''$ broad, and $\frac{1}{2}'''$ thick; the negative, $6''$ long, $7'''$ broad, and $6'''$ thick. Marcus puts together 32 elements in such a manner that all the positive bars are on one side, and all the negative bars on the other, and have thus the form of a grating. The battery consists of two such gratings, which are screwed together in the form of a roof, and strengthened together by an iron bar, mica being used as an insulator. The under sides of the elements are cooled by a vessel of water. The whole battery has a length of two feet, with a breadth of six inches, and a height of six inches. Marcus has constructed a furnace, which is calculated for a battery of 768 elements, which would correspond to a Bunsen's battery of 30 pairs, and consume 240 lbs. of coal per day. The Vienna Academy, recognizing the importance of the discovery, has voted to the inventor the sum of 2,500 guilders, the invention to be public property. *Pogg. Ann., April*, 1865; from "Amer. Journ. of Science" for Sept. 1865, the Editor of which appends the following note: —

"The importance of Marcus's invention, in a technical point of view, can hardly be over-estimated, since it promises to furnish the cheapest method of obtaining an intense light for light-houses and public buildings; and even holds out a prospect, perhaps not remote, of applications in domestic economy.

"It must be remembered that the step taken by Marcus is, after all, a first step in the right direction. Bunsen, E. Becquerel, and Stefan, have shown that there are thermo-electric combinations of much higher electro-motive force than those employed by Marcus, although the internal resistance is too great to permit of their use in constructing large batteries. If the progress of science should make us acquainted with metallic alloys, which, when combined and arranged as thermo-electric elements, develop electro-motive force as high as one-tenth of that of a Bunsen cell, the thermo-electric battery will again become a new instrument. In this connection, we suggest that the thermo-electric relations of the highly crystalline alloy of iron, manganese and carbon, known as 'spiegeleisen' (that from the Franklinite of New Jersey for example), deserve a careful study. The possession of a galvanic battery in which coal is consumed in place of zinc and acids, can hardly fail to revive an interest in electro-magnetic engines, like that of Page, even if only for cases in which comparatively little power is required, since our best steam engines do not yield ten per cent. of the work which the consumption of the coal is capable of doing."

WILDE'S MAGNETO-ELECTRIC MACHINE.

The principle is this: An armature wound round with insulated wire is made to revolve rapidly in front of the poles of a large permanent magnet. The currents of electricity, thus induced in the insulated wire, are carried round a large electro-magnet, which is thereby excited to a very high degree. In front of this electro-magnet, a second covered armature is rotated; and the electric current thus generated is carried round a third electro-magnet. It is from a rotating armature in front of this third magnet that the electric current, ultimately used for heating or lighting effects, is produced. At each passage round the electro-magnets, and induction in the rotating armatures, the electric current becomes magnified to an extraordinary degree, until ultimately it is powerful enough to melt iron bars in a minute or two, and to produce a light surpassing that of the sun itself. The machine is driven by means of a steam engine, and, as almost the only current expense is for motive power, it is not an improbable supposition that ere long electric lights of the most intense description will be as common in large factories and public buildings, as gas lights are at the present time.

The great advantages of this over the old system of magneto-electric machine appears to be that it is capable of amplification to any required power, by a mere enlargement of the size of the different parts. His largest machine weighs about three tons. If, instead of using the electric current generated by it to produce dynamic effects, we pass it round a still larger electro-magnet, we should at once produce a vastly greater development of force. The only limit which we see to this multiplication of power is the excessive heat which would be developed in the rotating armatures. One very interesting practical application of this brilliant and economical light is to photography, for which it is more convenient than the sun. By its aid more than two hundred negatives can be exposed in a day, to secure gelatine reliefs. This is the first practical application of the electric light to the commercial working of photography, its constancy rendering it here more valuable than an uncertain sunlight. — *Quarterly Journal of Science*, 1866.

ELECTRICITY AS A MOTIVE FORCE.

Mr. Moses G. Farmer, who has paid great attention to the origin and measure of electro-motive force, and the resistance which the current encounters in its passage through metallic wires and plates, has pointed out the numerical rules for computing the mechanical power derivable from a given consumption of metal in the battery, as compared with that furnished by an equal weight of coal; from which it appears that, until some much cheaper mode of generating electricity shall be discovered, this force cannot compete, as a motor, on a large scale, with the force derived from ordinary combustion.

PNEUMATO-ELECTRIC ORGAN.

Electricity has been very ingeniously and effectively applied to form a connection between the keys of an organ and the valves which permit air to pass to the pipes. Complicated mechanism is thus got rid of, an extremely simple arrangement, whatever the distance between the keys and the pipes, being substituted. According to the "Scientific Review," when any key is depressed by the finger, a small commutator under it completes communication with a galvanic battery, by dipping its lower ends into minute cups of mercury. Electricity then passes along a wire to a small electro-magnet, that immediately becomes excited, and, attracting a keeper, opens a valve, allowing air to pass into the organ-pipe, which sounds at once, and continues to do so as long as the finger presses down the key. It is clear that, however powerful the organ, or distant the pipes, the fingers are not in the slightest degree distressed in playing. The battery used is simple, inexpensive, and permanent in its action. It consists of glass vessels, arranged on the upper surface of the bellows, and each containing a solution of sulphate of mercury; into the latter plunges a plate of zinc, which is placed between two plates of gas retort graphite, when the bellows is raised by the action of blowing. No effect, therefore, is produced, except when required, which prevents waste of battery power. The zinc requires to be replaced, and the mercury, thrown down by the zinc which is dissolved, to be re-formed into sulphate, about every six months.

SUN-SPOTS *VS.* MAGNETIC VARIATION.

Father Secchi has just completed the reduction of the observations made during the years 1859 to 1865, inclusive, of the amount of magnetic variation, on the one hand, and of the number of groups of spots visible on the sun, on the other. The results are very interesting, as showing the intimate relation between the two phenomena, — a minimum of spots invariably corresponding to a minimum of magnetic variation.

DEVIATION OF THE COMPASS.

Mr. E. S. Ritchie read a paper before the Massachusetts Institute of Technology, in February, 1865, on the deviation of the compass, caused by the iron used in the construction of vessels, and the best mode to correct it. The causes of the disturbance are: 1. The presence of soft iron, which attracts equally each pole of the needle, with a force nearly constant in all positions of the ship on the earth's surface, and for all time. 2. The magnetism induced by the earth in iron placed in or near a vertical position, causing in the Northern hemisphere the lower end to become a North pole, while in the opposite hemisphere it becomes a South pole. 3. Magnetism induced in the iron by rolling, hammering, etc., during the building of the ship: this is more or less permanent according to the hardness and quality of the iron; and, among

other changes, is liable to be increased by the often-repeated strokes of the waves.

The method usually adopted to correct these deviations is, by so placing bar-magnets as to counteract the magnetism of the ship. But, as every vessel has its own magnetic peculiarities, — as in some vessels the error is comparatively small, or nearly constant for a considerable time, while in others the amount of deviation changes greatly and suddenly, — the bar-magnets, remaining constant in force, cannot be relied on to correct the deviation. The prevalent idea among shipmasters, that the deviation was necessarily of the same amount, and opposite in direction on opposite courses of the vessel, is erroneous, and the placing of the local magnets for correction in consequence of no avail.

It is of great importance that masters of vessels should make a table of errors for at least sixteen points of the compass, with a proper allowance therefor, and frequently verify or correct this table of errors, and test the course daily by means of the azimuth compass. If this precaution were used by all masters of vessels, not only would the list of disasters be very greatly reduced, but the length and expense of voyages, and the premium of insurance, would be diminished.

ACTION OF SULPHUR IN A NEW FORM OF VOLTAIC BATTERY.

M. Matteucci communicated to the French Academy of Sciences a memoir on the above subject, the chief points of interest in which are as follows: —

The author recently had his attention directed to the action of sulphur in a new form of battery invented by M. Blanc Filipo. This battery has for its positive electrode a plate of zinc plunged in a solution of common salt, and for the negative metal a plate of lead covered by electrolysis with a very thin layer of copper; enough flowers of sulphur were then mixed with the liquid in the cell to form a thin paste. The needle of a galvanometer, which had been included in the circuit, immediately began to move upwards: after some hours it reached nearly the same deflection as would be shown by employing a Daniell's cell of equal size, and remained at the same degree for four or five days, the circuit being closed during the whole of this time. At the end of this period, the layer of copper was found to have changed into sulphide of copper, and the liquid had become highly charged with sulphide of sodium, mixed with traces of sulphide of copper. The only disadvantage at present connected with this battery appeared to be, that, during its action, a small quantity of sulphuretted hydrogen was liberated: notwithstanding this, it is likely to be a most valuable instrument for telegraphic purposes.

M. Matteucci found that plates of platinum, iron, copper, silver, or any other electro-negative metal, when covered with a layer of copper, which is absolutely necessary, gave a constant current, similar to the coated plate of lead. When, instead of copper, the plates were coated with silver or lead, the same action took place, the metal being changed into its sulphide. With copper, however, the action was most prompt, intense, and permanent.

The author then shows, by experiments, that to obtain the proper effect of sulphur in the battery, it is necessary that the sulphur should be mixed with a solution of common salt, or with any other salt of soda, or probably with any alkaline base; it is also essential that the sulphur should come in contact with the copper. Experiments showed that this action of sulphur was subject to the fundamental law of the battery; for, taking into account the traces of sulphuretted hydrogen which are disengaged, and the very small quantity of sulphur which is combined with the copper, the conclusion was arrived at that the zinc dissolved, and the sulphur combined with the sodium, as protosulphide, in the exact ratio of their equivalents. Summing up his results, M. Matteucci arrives at the following conclusions:—

1. That finely-divided sulphur, placed in contact with the electro-negative metal of a battery composed of zinc, copper, and solution of common salt, notably augments the electro-motive force, the constancy and the duration of the battery. It is thus hoped, that, by the employment of sulphur, a voltaic combination may be obtained having many advantages over those batteries which are ordinarily used in industry.

2. The sulphur, though insoluble, and uncombined, enters into combination with the sodium set free by the electric current.

The action exercised by the small quantity of sulphide of copper which is formed still remains to be explained. This action appears to be essential to the battery. Instead, however, of offering any theory on this subject, M. Matteucci has undertaken further experiments to elucidate this point.

INDUCTION COILS.

At a recent meeting of the Royal Scottish Society of Arts, held in their hall, George Street, Edinburgh, Sheriff Hallard presiding, Dr. Ferguson read a paper on a new method of constructing induction coils, an abstract of which will be interesting to our readers. One peculiarity of the method consists in coiling the secondary wire round the primary coil, in lengths proportionate to the power of the primary coil at the point where the wire is coiled, there being least at the ends and most in the middle. By this construction, the length of the spark given by the induction coil is not purchased, as it generally is, at the expense of its volume. Another peculiarity is, that the wire is wound in two parts, separated by a diaphragm, and the poles stand at the same distance from the primary coil. Both poles are thus alike a power. In the usual arrangement, one pole is weak and the other strong. A coil constructed on this method by Mr. Hart, of College Street, was exhibited, which gave readily dense sparks of eight inches in length. The insulation of the coil has been so applied and protected as to secure the permanent power of the coil. The length of the wire on the secondary bobbin is nearly seven miles. Another paper on a new current interrupter for the induction coil, also by Dr. Ferguson, was read. In this contrivance, a spiral of copper wire, free to oscillate in the middle, is fixed at its end to

a rod of iron as a case. A wire, soldered to the coil, comes out at right angles from it; and, being bent down at the end, dips into a cup containing mercury. The battery connection is so arranged, that when the dipping wire is in the cup the galvanic circuit is closed. On the closing of the circuit, the dipper is drawn out of the cup, and the circuit is thereby broken; and the coil, under the action of its electricity, returns to its former position. The dipper is thus alternately lifted up, and plunged into the cup, and a rapid series of interruptions is made. This interruption admits of a simple and perfect system of regulation, so that it can be made to move at any speed. It does away with the armature and spring of ordinary self-acting brakes, is quite continuous, and introduces almost no resistance into the primary circuit. The interruption was used with the coil, and several experiments illustrative of the merits of both were performed.

ELECTRIC SIGNALS ON RAILROADS.

Before the Institution of Civil Engineers, an interesting paper was read by W. H. Preece, Associate, "On the best means of communicating between the passengers, guards, and drivers of trains in motion." Mr. Preece explained that the essential principle of the system he had introduced in the trains of the South Western, the Midland, and the Great Northern, was the extension of a single isolated wire throughout the whole train, which was maintained in a state of electrical equilibrium by having the similar poles of every battery in each van and engine attached to it, while their opposite poles were connected with the earth, so that when this equilibrium was disturbed by placing the wire to earth through the framework, wheels, and rails in any carriage or van, the current from each battery acted upon the bell in its own van, and upon a signal on the engine. Its peculiarity consisted in this, that the commutators in each compartment of every carriage were protected from the mischievous and idle by being covered with glass, which had been found experimentally to be the best material for the purpose, as any opaque substance excited inquisitiveness and interference.

MUTUAL ACTION OF ELEMENTS OF ELECTRIC CURRENTS.

The law of Ampère — that commonly recognized as expressing the action of two independent elements (or infinitesimal portions of electric currents) — was based on a certain assumption, and on four cases of equilibrium experimentally determined. The assumption of Ampère was, that the direction of the action was constant, independent of the relative direction of the elements, and that the quantity or intensity of the action varied with the direction of the elements. The new assumption is the reverse of this, to wit, that the intensity of the resultant is independent of the direction of the elements; but that the direction of the resultant varies with that of the elements. The latter view more closley

corresponds to the doctrine, now generally admitted as established, of the correlation of the physical forces. It is also, in form, more closely analogous to the law expressive of the mutual action of material masses under the influence of gravity.

In the case of gravity, the action was proportioned directly to the product of the masses, and inversely to the square of their distance. In the case of electrical currents, the direction of the elements is to be taken into consideration; and the resulting force may be expressed as the product of the quotients of each element (considered both as to strength of current and length and direction of the element), divided by their distance (also considered both as to length and direction). The consideration of direction involves the application of the newly-developed principles of the mathematical science of quarternions.

The law above mentioned being assumed, all of the other ordinary special laws of electrical action flow readily and necessarily therefrom; as, for example, the mutual action of closed circuits, and the action of magnets considered as solenoids.—E. B. Elliot, *in Proc. Am. Ass'n, for Adv. of Science*, 1866.

INSTRUMENT FOR SHOWING MINUTE CHANGES OF MAGNETIC DECLINATION.

Dr. Joule described, before the Literary and Philosophical Society, an instrument he had constructed for rapidly showing minute changes of magnetic declination. A column of small magnetic needles is suspended by a filament of silk. Attached to the lower end of the column is a glass lever with a hook at its end. A second fine bent glass lever is suspended by another filament of silk; its shorter arm being connected with the first lever by means of the small hook. The whole is enclosed in a stout copper box. Light is admitted into the box through a lens, cemented into an orifice immediately under the object-glass of a microscope, placed over the free extremity of the bent lever. The microscope magnifies about three hundred linear, and has a micrometer in its eyepiece, with divisions corresponding to one two-thousandth of an inch. One division corresponds to a deflection of the needle of four and one-half minutes, and, as a tenth of a division can be very readily observed, the instrument measures deflections to within half a second. So rapid is the action, that, on applying a small magnetic force, the index takes up its new position steadily in two seconds of time. Besides being a damper to the motion of the needle, the copper box, by its conducting power, equalizes the temperature rapidly, so that the indications are not to any considerable extent disturbed by currents of air. The success of the present instrument encourages the hope that very much greater delicacy may yet be obtained. Dr. Joule said that he had observed an extensive magnetic disturbance the preceding evening, the index being driven entirely out of the field of view.

ELECTRICAL FLYING FISH.

The experiment of the "flying fish" has excited attention in Paris. M. l'Abbé Laborde and M. Salleron have both written to "Les Mondes" on the subject. Each suggests making use of the conductor of an electrical machine in place of a charged Leyden jar. M. l'Abbé Laborde says, in the following manner the experiment can be easily made by any who possess an ordinary electrical machine: A piece of gold leaf or silvered paper is cut into the shape of a kite; this is then placed on the conductor of a machine, and a ball connected with the rubber slowly approached to the blunt end of the leaf. Soon the leaf rises and springs from the conductor, remaining hovering in the air between it and the ball. The finger can be substituted for the ball, and the leaf led even vertically round the conductor with a considerable intervening space. The distance of the leaf from the rubber almost entirely depends upon the size of the blunt angle, — the more obtuse this angle, the nearer the leaf approaches to the rubber. The explanation given by M. l'Abbé Laborde is, that the point presented to the electrified body, receiving electricity of the same name, is repelled, which it would be altogether, were it not that it parts with its electricity by the other point, can be again attracted to the electrified body, and is again repelled. Thus repulsion takes place in approaching the conductor, because it receives more than it loses; but immediately attraction ensues, because now it loses more than it receives. The equilibrium between these two opposing forces enables the gold leaf to maintain itself in the air at a distance from both solid bodies.

ELECTRICITY IN DEEP-SEA SOUNDING.

In deep-sea sounding, the greatest difficulty is felt, even by experienced persons, in ascertaining the precise moment at which the lead of the sounding-line touches the bottom, — a matter on which the whole value of the sounding depends. An apparatus invented in France, at Lyons, removes, it is said, every difficulty on the point. The sounding-line contains within it, along its whole length, two insulated conducting wires, the upper ends of which are connected respectively with the poles of a galvanic battery in the ship. The lead is in two parts, the lower one of which is partly inserted into the upper, and is capable of a limited vertical motion within that of the other, so that, when left to hang freely, a small empty space is left within the upper portion by the spontaneous descent for a short distance of the lower portion. To the upper end of the lower portion, and within the upper portion, is attached a commutator, which is contained in an insulating and water-proof sheath, and which, when the lower portion of the weight is raised by contact with the ground, comes in contact with the ends of the conducting wires, so as to complete the circuit. Instantly, by means of the ordinary electro-magnetic apparatus, a bell is rung on board the ship to attract the attention of the sounder, and a ratchet is thrown into action, which arrests the unwinding of the

line from the drum on which it is coiled, so that no more can run out. This apparatus is applicable also when the lead is kept hanging down at a certain distance from the ship, for the purpose of indicating the presence of rocks or reefs, or that the water has become shallow, so as to give timely notice of approaching danger. — *Scientific American.*

LIGHTING OF THE CAPITOL DOME.

The efforts of Mr. Samuel Gardiner, of New York, in this enterprise have been crowned with triumphant success. For two years and a half the arrangements have been quietly perfecting, and on the evening of the 23d of January, 1866, the dome was illuminated from three circles of burners, invisible from the floor, and containing 1100 jets, from 6 to 12 inches apart, bringing out in splendid relief the picture executed by Mr. Brumidi on the ceiling of the inner dome, at a height of 180 feet from the floor of the rotunda.

The means for operating the battery, turning on and off the gas, and lighting each tier of burners, are brought within a space of two feet square in a passage-way within a few feet of the floor of the rotunda, and consists of a silver-mounted dial-plate with keys, eleven in number, one in the centre, by which the primary connection is made, and the required amount of battery brought into operation, the others being for the gas and lighting connections of the respective tiers. These tiers, it may be here mentioned, are three in number at present; the first, containing 300 burners, at the lower cornice, 45 feet from the floor; the second, of 325 burners, at a cornice 80 feet from the floor; the third tier, 425 burners, 165 feet from the floor, surrounding the balustrade, and near the margin of the picture on the ceiling.

The first and second series of burners are entirely inaccessible, all are invisible from any part of the floor, and every possible manipulation is executed at the dial-plate on the floor by the exertion of a few ounces pressure on the appropriate key, the gas stop-cock to each tier being operated by an electro-magnetic engine in its vicinity, which receives its impulse from the battery, the central heart of the concern, communicating light, heat, and force, under the guidance of the brain which directs the current at will through the five miles of wire. This heart of the apparatus, whose impulses are thus directed, is housed in and fully occupies an elliptical room 45 by 36 feet, and consists of 200 jars, arranged on tables in concentric series, each jar being 13 inches in diameter, 14 inches deep, and so arranged as to be thrown on or off in sections of 20, by the key on the before-named dial-plate in a passage remote from the battery. A vernier on the dial-plate, in connection with a pointer on the central key, indicates the extent of the battery which is brought into operation by the revolution of the key. Openings in the dial expose dark and light segments of the wheels on the gas keys, so as to indicate the shut or open positions of the gas stop-cocks at the tiers 45, 80, 165, and the

cluster 264 feet above. Owing to the height, a gas regulator is provided at the stop-cock of each tier, which equalizes the flow. No. 10 copper wires are used throughout; and, after being wrapped with linen, are inclosed in India-rubber tubing, and incased, or otherwise secretly laid, passages in the walls being drilled therefor through a thickness of from 3 to 20 feet. The return circuit is made through the gas pipes, saving a duplication of the nine thousand yards of wire. The burners used have an indestructible lava tip, which acts as an insulator, and each is provided with an insulated coil of platinum wire on one side of the orifices, so as not to interfere with the free exit of the gas, while exposing one side of the jet to the action of the red-hot metal when the electric connection is made.

The experiments have covered a period of nearly ten years, and six patents cover the main features of the invention. The experiments, on so grand a scale as the Capitol dome, with 1100 burners, at such distance and elevation, settle the question of success; and the invention will come into general use for lighting theatres, concert and public halls, and eventually, by large central batteries, will ramify over city districts, to afford to residents, merchants, and manufacturers, a connection for the purpose of instantaneous illumination to any extent desired. — *Scient. Am.*

PROTECTION AGAINST LIGHTNING.

The present summer, so far, has been remarkable for the number of accidents from discharges of electricity. We believe there has been no storm this season, accompanied with lightning, which has not resulted in damage to person or property. In view of these facts, the importance of providing adequate protection to buildings and ships, from lightning, can hardly be over-estimated. The failure of lightning-rods, in some instances, to protect the structure to which they were attached, has had the effect to impair confidence in such means of protection; but it can be clearly demonstrated that, when made on scientific principles, honestly constructed, and properly applied, they are the only means which can be relied upon for protection, and that they are deserving of entire confidence.

The electric fluid does not always descend in a vertical path, nor in a course approaching that direction. Many instances are on record where the bolt travelled horizontally, and much damage has occurred from "earth strokes" or ascending discharges. These facts have not always been recognized by constructors of lightning-rods, their idea being that a building was sufficiently insured against lightning by having the rods project above the highest portion of the building, leaving all the other parts unprotected. Experience has added its evidence to the instructions of science in demonstrating the unreliability of such protectors.

From Lyon's "Treatise on Lightning-Conductors," we copy the following requisites of a good rod: —

"1. The conductor should be made of good conducting substance.

"2. It should have great electrical capacities; a square rod requires less metal than a round rod.

"3. It should be perfectly continuous, *i. e.*, it should have no breaks in the connections,—no links or hooks, but a perfect metallic union of every part.

"4. It should be insulated from the building to be protected, except from such masses of metal as are likely to offer other lines of discharge.

"5. It should have numerous lateral points; one in six or seven feet will answer. The more numerous these points are, the greater the conducting power of the rod. Besides, these lateral points provide for an oblique discharge, each being as good a receiving point as the higher point at the chimney or other prominences. They also guard against a lateral explosion, or a division of the charge, which is liable to happen in case the rod is overcharged, especially if it be fastened to the house with pointed staples; and, in case of an upward stroke, the electric fluid being discharged at so many different points, no harm can possibly occur.

"6. Its upper extremity should project freely into the air, should be pointed, and may be triangular, somewhat similar to a bayonet, or it may have several branches. The only scientific advantage in having a branching head or point for the superior termination is this: all points are not likely to become blunt at the same time. Some have supposed that the point should be magnetized; and little needles, called "magnets," have sometimes been added. But it is difficult to see the practicability of this recent discovery; for most are aware that magnetized iron or steel soon loses its magnetic influence. But is there any truth or science in this application of magnetism? If there is, we confess that we have not been able to discover it in any experiments in the laboratory; neither can we learn that the subject has even been mentioned by any writer whatever on the subject of electricity.

"7. The upper termination should be plated with silver or gold, to prevent corrosion.

"8. Every branch rod running to chimneys and other prominences should have a perfect metallic union with the main rod.

"9. In cases where metallic vane spindles, or other points, exist, the conductor may commence from these, and should be applied immediately to the part to be protected, and not at a distance from it; and should be so applied that a discharge of lightning falling on the general mass could not possibly find its way to the ground through the building by any circuit of which the conductor did not form a part; that is to say, the conductor should be so carried over the several parts of the building, that the discharge could not fall upon it without being transmitted safely by the conductor. Hence, the rod should run along the whole length of the ridge, and down to the ground, at least on two sides of the building. If the building is large, it should run down on each corner.

"10. Every conductor running to the ground should terminate

sufficiently beneath the surface to insure moisture in the dryest part of the season. If circumstances permit, it should connect with a spring of water, a drain, or some other conducting channel."

Numerous instances of the ascending stroke have occurred, the records of which are extant. It must be evident that a single rod, extending above only one point of the building, will not properly protect the structure to which it is applied from one of these upward strokes, neither is it efficient against an oblique or divided discharge. The whole building, top and sides, must be protected by a continuous rod with numerous projecting points for receiving and discharging the electric fluid.

Passing the rod through glass insulators does not seem to be always effectual to protect the building. The interposition of a glass knob between the rod and the building, appears to be preferable. In cases where the rod has passed through a hollow cylinder of glass, it has been found that the glass would burst, and the fluid enter the building by the iron staple which held the glass ring.

Some of the old-fashioned and erroneous notions entertained and religiously believed by persons in relation to the effects of lightning, and particularly the means of protection, have been exploded by the occurrences of this season. That feathers afford no protection against electricity is proved by the case of a woman in St. Louis, who was killed by a stroke of lightning while lying on a feather bed. An instance of one of three persons sitting near a closed window being struck also dispels the illusion that the interposition of window-glass is an effectual bar to the action of the destructive element.

The only efficient protection is that of a good rod, properly put up. The subject is too important to be lightly passed over; and it is no less important that the confidence of the purchaser should not be betrayed, and life and property endangered, by accepting an inefficient conductor, or one improperly applied.

Many buildings are now constructed, both in this city and in the country, with metallic-covered roofs, and very few are erected without metallic eaves, troughs, and conductors. In all such cases, the efficiency of lightning protectors is impaired by the preponderance of conducting surface on the roof and down the sides of the building. This metallic covering, and these rain-conductors, whether of tin, zinc, or lead, are better conductors of electricity than the building of stone, brick, or wood, and should be utilized as a means of protection against lightning. For this purpose, strips of iron, zinc, or copper, should connect the lower extremities of the water-spouts with the damp earth, a well, or a running stream of water, and the eaves-troughs should have a connection with the metal roofing and with the vertical conductors. Water is a good conductor of electricity; and when, in a thunder storm, the rain is pouring down the conduits of a building, their conducting properties are largely increased. Properly connected, these useful appliances can be madé doubly valuable as harmless conductors of electricity.

In cities and enterprising towns there are systems of water-pipes and gas-conductors, of metal, ramifying in the interior of dwellings and other structures. Such buildings should be carefully protected outside. If the conducting medium, whether of water or gas-pipes, preponderates in the interior of the building, the electric fluid may leave the external conductor, and through a thick wall seek that which facilitates its passage to the earth. In such cases, it seems that nothing but a rod, having numerous points for collecting the electricity and adequate means for conveying it innocuously to the earth, would be an effectual protection. Some authorities recommend a connection to be made between the system of water and gas-pipes inside a building and the external conductor. — *Scientific American.*

ALL THINGS IN MOTION.

In imagining the ultimate composition of a solid body, we have to reconcile two apparently contradictory conditions. It is an assemblage of atoms which do not touch each other, — for we are obliged to admit intermolecular spaces, — and yet those atoms are held together in clusters by so strong a force of cohesion as to give to the whole the qualities of a solid. This would be the case even with a solid undergoing no change of size or internal constitution. But solids do change, under pressure, impact, heat, and cold. Their constituent atoms are, consequently, not at rest. Mr. Grove tell us: "Of absolute rest, nature gives us no evidence. All matter, as far as we can ascertain, is ever in movement, not merely in masses, as with the planetary spheres, but also molecularly, or throughout its most intimate structure. Thus, every alternation of temperature produces a molecular change throughout the whole substance heated or cooled. Slow chemical or electrical actions, actions of light or invisible radiant forces, are always at play; so that, as a fact, we cannot predicate of any portion of matter, that it is absolutely at rest."

The atoms, therefore, of which solid bodies consist are supposed to vibrate, to oscillate, or better, to revolve, like the planets, in more or less eccentric orbits. Suppose a solid body to be represented by a swarm of gnats dancing in the sunshine. Each gnat or atom dances up and down at a certain distance from each other gnat, within a given limited space. The path of the dance is not a mere straight line, but a vertical oval — a true orbit. Suppose, then, that, in consequence of greater sun heat, the gnats become more active, and extend each its respective sweep of flight. The swarm, or solid body, as a whole, expands. If, from a chill or the shadow of a cloud, the insect's individual range is less extensive, the crowd of gnats is necessarily denser, and the swarm, in its integrity, contracts.

Tyndall takes for his illustration a bullet revolving at the end of a spiral spring. He had spoken of the vibration of the molecules of a solid as causing its expansion, but he remarks that, by some, the molecules have been thought to revolve round each other; the communication of heat, by augmenting their centrif-

ugal force, was supposed to push them more widely asunder. So he twirls the weight at the end of the spring, in the open air. It tends to fly away; the spring stretches to a certain extent, and as the speed of revolution is augmented, the spring stretches still more, the distance between the hand and the weight being thus increased. The spring rudely figures the force of cohesion, while the ball represents an atom under the influence of heat.

The intellect, he truly says, knows no difference between great and small. It is just as easy, as an intellectual act, to picture a vibrating or revolving atom as to picture a vibrating or revolving cannon ball. These motions, however, are executed within limits too minute, and the moving particles are too small, to be visible. Here the imagination must help us. In the case of solid bodies, you must conceive a power of vibration, within certain limits, to be possessed by the molecules. You must suppose them oscillating to and fro; the greater amount of heat we impart to the body, the more rapid will be the molecular vibration, and the wider the amplitude of atomic oscillation. —*All the Year Round.*

CORRELATION OF THE PHYSICAL FORCES.

There are signs of some reaction against that doctrine of the correlation of the physical forces which, for the last twenty years, has so dominated scientific thought, or, at least, against that interpretation of it which makes it teach that all forces are modifications of one force, and are mutually convertible into each other. Thus, in the last number of the "Quarterly Journal of Science," a mention, in an article on "De La Rue and Celestial Photography," of the appearance in the photographs of the solar eclipse of 1860 of solar prominences invisible to the human eye, calls forth the following very noteworthy remarks: "A curious question arises from the consideration of the chemical power evidently possessed by these prominences, be they flames or clouds. We never, as we have already stated, under ordinary circumstances, obtain an impressed image of the sun without finding the indications of a protected circle — that is, one which proves a paucity of chemical power — surrounding the photographic disk. Yet, when the light of the solar disk is interrupted by the body of the moon, the radiations proceeding from the edge, or rather, perhaps, from beyond it, have a strong photographic power. What is the cause of this most remarkable difference? Why is it that the photographic tablet is impressed during an eclipse by objects which do not give light enough to be visible even at the period of totality, and that they do not effect the required chemical change upon our sensitive plates when the sun is unobscured? The only reply which we are at present in a position to give, is, that the diffused light when the sun is shining is sufficiently powerful to overcome the weaker chemical radiations of those solar clouds or flames. If this reply approaches correctness, we have additional evidence confirming the view that the two principles existing in the sunbeam, light or luminous power, and actinism or chemical power, are not modifications of the same 'energy,' to use the accepted term of the day,

but rather forces balanced against each other, acting indeed in antagonism."

THE PHYSICS OF ABSORPTION.

The curious fact pointed out by Pouillet, in 1822, that when a fluid is absorbed by a porous substance a rise in temperature occurs, has given origin to some strange explanations and discussions. The subject has recently been taken up by Jungk, who attributes the alteration in temperature to the formation around each particle of the porous body of a thin layer of fluid, "in which the individual molecules move with much less freedom; thus pointing to a condensation of the fluid in those parts." In support of his theory, he quotes a paper by Rose, on the errors which arise in the determination of the specific gravity, when the substance is weighed in a state of fine subdivision. The finer the particles of the body under examination, the greater will be the resulting specific gravity. He proceeds by assuming that the temperature of a body rises or falls when, by any external means, it is caused to assume the condition induced by the subtraction or addition of heat respectively. Applying this in the case of water, it would follow that, when absorbed by a porous substance, the temperature should either rise or fall according as the water is below or above four degrees Centigrade, — the point of maximum density. This, in fact, was found to be the case; and the results of his experiments may be shortly stated as follows: 1. The temperature of water, when absorbed by sand, is raised or lowered according as it was previously either above or below four degrees C. 2. Water at zero, when absorbed by snow, is lowered in temperature. 3. The phenomenon may be regarded as a consequence of the condensation of the water on the surface of the absorbent body. — *Poggendorff's Annalen*, 1865.

LIFE-TABLES.

A paper entitled "New and Compendious Method for the Construction of Life and Annuity Tables from Returns of Population and Mortality," was read by Mr. E. B. Elliot at the 1866 meeting of the American Association for the Advancement of Science.

He remarked that life-tables assume various forms, the more common form being that which gives the number surviving different ages out of a given number of persons living at some earlier age specified.

The population of any community is usually a fluctuating one; it varies with the excess of births over deaths, and of immigration over emigration.

A stationary population is one unaffected by migration, and in which the births are equal in number to the deaths, the number of persons annually entering upon any age being equal to the number of deaths which annually occur at and over that age. Hence, if we have either the number of annual deaths or the number of the living at different ages in a stationary population, we have in desirable form life-tables for that population.

The problem then is, given the annual number of deaths at different ages in a fluctuating population, and the numbers of the population at the same ages at the middle of the year; required, the corresponding relative number of deaths and of living in a stationary population governed by the same law of mortality.

The usual modes of affecting this conversion are indirect and tedious; the method now proposed is direct and brief, reducing the labor of weeks to that of hours.

This important result is accomplished by observing that the rates of annual mortality at different intervals of age are equivalent to the derivative (or differential co-efficient) of the Napierian logarithm — taken negatively — of the proportionate numbers of the living at those ages, in a stationary population.

Taking advantage of this fact, Mr. Elliot showed how, by very simple processes, desirable forms of the life-table might readily be computed.

THE PHILOSOPHY OF A TOP.

The reason why a top stands in an erect position when it is in a spinning motion is explained by the "Scientific American" in the following manner: —

"The same explanation that we gave, some time since, of the gyroscope, applies to a top. If you tie a stone to the end of a string and swing it about your finger, then, while it is whirling, if a sheet of thin paper be held so that the stone will strike it at a sharp angle in a way to turn the stone from the plane of its revolution, the stone will resist this effort to turn it from its course, and will pass through the paper. If a sufficient number of stones are united to form a complete wheel, and the wheel is put in rotation, each one of the stones will resist any effort to change the plane of its revolution; and thus the whole wheel will resist any effort to change the plane of its rotation. When a top is rotating in an upright position, it cannot lean toward any side without changing the plane of rotation of all its parts; consequently, so long as it is rapidly rotating it stands upright.

"When the axis of the top is inclined, the force of gravitation tends to draw it downwards, and thus to change the planes of rotation of all its parts. If you will take a wheel, and incline its axis, you will see that the struggle to resist this change will move the wheel forward, and will thus give to it a revolution around an imaginary vertical axis. Even in this revolution the planes of rotation are constantly changed, but the change is the less the more nearly the axis of the top coincides with the imaginary vertical axis about which it is revolving; hence it is subjected to a constant tendency to assume an upright position, and the more rapid its rotation, the stronger is this tendency.

"The resistance offered by a rotating wheel or disk to any change in the plane of its rotation is worthy of consideration in many applications of mechanism. This resistance tends to make a fly-wheel run true, and, consequently, to so wear its bearings as to correct any slight error in its original hanging. It increases the resistance of locomotive and car wheels to the change in the

direction of their motion in passing round a curve. It precludes the employment of Avery's engine for driving locomotives, and suggests that, if his engine should be used for this purpose, it should be run on a vertical, instead of horizontal, axis."

WORKING STEAM EXPANSIVELY.

The following is a letter from Prof. Rankine, of Glasgow, to the editor of the "Scientific American," in 1866: —

"The circumstances under which steam undergoes expansion may be classed under five heads: 1. When the steam expands without performing work. 2. When it expands and performs work, the temperature being maintained constant by a supply of heat from without. 3. When it expands and performs work, being supplied from without with just enough of heat to prevent any liquefaction of the steam, so that it is kept exactly at the saturation point. 4. When it expands and performs work in a non-conducting cylinder. 5. When it expands and performs work in a conducting cylinder, not supplied with heat from without.

"1. When steam expands without performing work (as in rushing out of a safety-valve, or through a throttle-valve), it becomes superheated, as is well known; the temperature falling very slightly in comparison with the boiling-point corresponding to the diminished pressure. The precise rate at which the temperature falls is not yet known; but it will probably be soon ascertained through some experiments by Prof. Thomson and Mr. Joule.

"2. When steam expands and performs work, the temperature being maintained constant by supplying heat through the cylinder, the law of expansion at first deviates from Marriotte's law by the pressure falling less rapidly than the density; but, as the expansion goes on, the law approaches more nearly to that of Marriotte, as recent experiments by Messrs. Fairbairn and Tate have shown.

"3. When the steam expands and performs work, being maintained exactly at the temperature of saturation, the law of expansion, as you observe, is perfectly definite. In the treatise to which you have referred, I have shown what it is; and also that it is expressed, nearly enough for practical purposes, by taking the pressure as being proportional to the seventeenth power of the sixteenth root of the density; a function very easily calculated by means of a table of squares and square roots. In many actual steam-engines, the circumstances of this case are practically realized, as is shown by the agreement of their performance with the results of calculation.

"4. When steam expands and performs work in a non-conducting cylinder, it was shown by Prof. Clausius and myself, in 1850, that the lowering of the temperature, through the disappearance of heat in performing work, goes on more rapidly than the fall of the boiling-point corresponding to the pressure, so that part of the steam is liquefied. This result was experimentally verified by Mr. G. A. Hirn, of Mulhouse, a few years afterward

(see his "Treatise on the Mechanical Theory of Heat"). The mathematical law of the expansion in this case can be given with perfect precision; but its circumstances are not accurately realized in practice, because the cylinder is always made of a rapidly-conducting material.

"5. When the steam expands and performs work in a conducting cylinder, which receives no supply of heat from without, but is left to undergo a great alternate rise and fall of temperature through its alternate connection with the boiler and the condenser, the law of expansion becomes very variable, and the problem of determining it extremely complex. It is certain, however, that a great waste of heat occurs in every case of this kind, as Mr. Isherwood's experiments have shown. In a paper read to the Institution of Engineers in Scotland, about two years ago, I discussed some of Mr. Isherwood's earlier experiments, and showed that they gave proof of a waste of heat increasing with the fall of temperature due to the expansion of the steam, with the extent of conducting surface of the cylinder, and with the duration of the contact between the hot boiler steam and that conducting surface."

NEW DETECTOR OF FIRE-DAMP.

Mr. G. F. Ansell, of the Royal Mint, has proposed a novel application of Professor Graham's law of gas diffusion for the purpose of ascertaining and giving warning of the presence of accumulations of fire-damp in coal mines. The apparatus described by Mr. Ansell is a glass U tube, having one aperture closed with a plate of graphite, or equivalent porous diaphragm, and a few inches of mercury in the bend. If such an arrangement, filled in the first instance with air, be placed under the influence of an atmosphere containing five per cent., or even less, of light carburetted hydrogen or marsh gas, the presence of such admixture will be instantly detected by the passage of the gas through the interstices of the graphite, and the consequent expansion in volume of the gaseous contents in the tube; the column of mercury then rises in the opposite limb of the apparatus, and is made to record itself either by completing the circuit of a voltaic alarum, by deflecting a galvanometer needle, or, lastly, by the adaptation of the simpler mechanism of a wheel barometer. We understand that the invention has been patented by Mr. Ansell, and, inasmuch as it gives great promise of successful employment, the apparatus must be deemed well worthy of immediate trial. — *Reader.*

CONTROLLING CLOCK.

Mr. Lang, C.E., in a paper read before the Royal Scottish Society of Arts, proposes a new method of adjusting a clock to within a small fraction of a second, which may perhaps be found useful in the case of a controlling clock, where it is important not to throw the controlled clocks out of time. It consists essentially in varying the virtual length of the pendulum by a very small

amount for a known time, according to the quantity the clock is fast or slow. The suspending spring passes through a fine slit in a piece of steel, which is capable of being raised or lowered by a cam to a certain extent. An index in the axis of the cam, moving over a dial, shows the extent to which the pendulum has been shortened or lengthened. Suppose the clock to be thirteen-hundredths of a second fast; the index is to be turned so as to point to the word *losing* on the dial, and allowed to remain there for five minutes twelve seconds, in the example given by Mr. Lang. At the end of this time it must be turned back so that the index points to *mean rate.* By this operation the clock is put back to true time.

DEPTHS OF THE SEA.

A French journal says that the soundings for the new trans-Atlantic cable have enabled comparisons to be made of the depths of the different seas. Generally speaking, they are not of any great depth in the neighborhood of continents. Thus, the Baltic, between Germany and Sweden, is only 120 feet deep; and the Adriatic, between Venice and Trieste, 130 feet. The greatest depth of the channel between France and England does not exceed 300 feet, while to the southwest of Ireland, where the sea is open, the depth is more than 2,000 feet. The seas to the south of Europe are much deeper than those in the interior. In the narrowest part of the Straits of Gibraltar the depth is only 1,000 feet, while a little more to the east it is 3,000 feet. On the coast of Spain the depth is nearly 6,000 feet. At 250 miles south of Nantucket (south of Cape Cod), no bottom was found at 7,000 feet. The greatest depths of all are to be met with in the Southern Ocean. To the west of the Cape of Good Hope, 16,000 feet have been measured, and to the west of St. Helena, 27,000. Dr. Young estimates the average depth of the Atlantic at 25,000 feet, and of the Pacific at 20,000.

FRACTURING CAST-IRON WITH WATER.

Advantage has recently been taken of the non-compressibility of water, to effect the reduction of large masses of cast-iron in France. The method, which is simple and ingenious, consists in drilling a hole in the mass for about one-third of its thickness, and filling the hole with water; then closing it with a steel plug which fits very accurately, and letting the ram of a pile-driver fall on the plug. The first blow separates the cast-iron into two pieces.

AMSDEN'S HYDROSTATIC SCALE.

The simple principle of this scale, viz., that a floating body sinks in water until it has displaced a quantity of water equal in weight to itself, is as old as Archimedes; the scale of Mr. Amsden therefore acts by the displacement of the water, and not by hydraulic pressure. It claims to supply the very important desid-

eratum of correctly ascertaining, in a minute or less, the exact weight of vessels of all descriptions, with their cargoes, at all times when at rest in the water, whether salt or fresh. It indicates not only any diminution or addition to the cargo, thus preventing frauds in transportation, but also reveals at a glance the condition of the vessel as to leakage on the voyage, thus contributing, by an "alarm" easily adapted, to the safety of passengers, and the preservation of freight. It is of great value in cheapening freight, increasing accuracy of measurement, and avoiding damage to boats by the racking in the old-fashioned weigh-locks, the last item being often a quarter of the worth of the cargo.

RESISTANCE OF WATER TO FLOATING AND IMMERSED BODIES.

At the Nottingham meeting of the British Association, Prof. Rankine read the report of the committee appointed to make experiments on this subject, giving the results of two hundred and twenty experiments. The committee have deferred for the present deducing any general laws of resistance; but he stated that the results of the experiments led to the following general conclusions: 1. That, agreeably to what was previously known of the behavior of small bodies at low speeds, the resistance increased on the whole somewhat more slowly than as the square of the velocity. 2. That, when the velocity went beyond the maximum velocity suited to the length of the model, as ascertained by Mr. Scott Russell's well-known rules, the resistance showed a tendency to increase at a more rapid rate. 3. In all cases the resistance seemed to be much more nearly proportionate to the main girth than to the midship section.

Mr. Bailey and Admiral Belcher having spoken with disapproval of hollow lines or wave-lines at the bows of sea-going vessels, Prof. Rankine pointed out, that the wave-line theory consisted of two branches, one relating to the form of the bows, the other to the relation between the length of the vessel and the speed at which she was to be propelled through the water. He did not attach much weight to the hollow bow, but thought that much was to be said in favor of the theory that the length should have a certain relation to the speed.

NON-RECOIL GUN.

Mr. G. P. Harding has recently experimented on a gun on a principle so new, that, if his expectations are fulfilled, the manufacture of fire-arms will be revolutionized. His gun is a simple cylindrical tube, without any breech. The shot is placed at the centre, the charge behind it confined by a wad, and a second wad is introduced at such a distance as to leave an air-space behind the charge. The extraordinary fact developed by Mr. Harding's experiments is this: That, although the gun is equally open in both directions, almost the whole force of the explosion takes effect on the shot, which attains the same velocity as if fired from

an ordinary gun, and is followed by the gases generated in the gun, a very small part only escaping at the breech. Mr. Harding's theory of the action of his gun is this: That compression of the air in the air-space behind the charge occupies an appreciable time, during which the force of the explosion has been communicated to the shot. But it is obvious that his results, if confirmed, will require a new examination of the action of powder in close chambers, our present knowledge being insufficient for their adequate explanation. In the meantime Mr. Harding has made several hundred experiments, which are certainly interesting and probably important. Of course, in such a gun, there is no recoil; and hence the name he has given it. — *Popular Science Review, July*, 1866.

PRODUCTION OF ICE CYLINDERS BY PRESSURE THROUGH ORIFICES.

The experiments of M. Fresca were made by acting on ice contained in a cylinder 0.16 metre (about 6 inches) in diameter, with the pressure necessary to drive it through a central opening in its base 0.05 metre (nearly 2 inches in diameter). The plates, prepared in Tyndall's method, in some cases colored at the joints, acted like plates of lead or of porcelain paste, as before explained by the author to the French Academy. The surfaces of the planes of division or joints, originally flat, were transformed into tubes concentric and perfectly distinct from each other, thus indicating the movement of each point of the mass during the change. The ice cylinders were longitudinally furrowed, the furrows appearing to proceed from fractures produced at the moment when a portion of the cylindrical block leaves the orifice, and when, consequently, it ceases to be subjected to pressure at the outer extremity. The evenly bedded structure of the cylinder of ice shows that the origin of these fractures is subsequent to the formation of the cylinder. For a block of the dimensions above given, the pressure required for the flow of the ice is 10,000 kilogrammes, one-fifth of that required for lead; this pressure corresponds for the square centimetre to 126 kilogrammes, or to a column of water 1,300 metres high.

The phenomena attending the formation of these ice cylinders seem to throw light on the question of the movement of glaciers. The relative displacement of the layers of ice in the process, the change of form in the flat faces, the curved form of the beds at the end of each partial tube, the large cavities formed toward these ends, and the fissures or fractures at the moment of escape from the pressure, are so many points of resemblance to the phenomena of glaciers. Though there is not the mass of material forming moraines, the traces of coloring matter, deposited in parallel threads and reunited toward the axis, complete the analogy. — *Les Mondes, Feb.*, 1865.

EXPANSION OF ICE.

The Rev. Frederic Gardiner contributed a paper to the "American Journal of Science," vol. 40, 1865, on the formation of ice in the Kennebec River, in the town of Gardiner, Me., in February and March, 1865. The river here is about 700 feet wide; the water is entirely fresh for many miles below, and the average ebb and flow of the tide is 5 feet; the depth of the water varies, according to the locality and the state of the tide, from 17 to 25 feet. In the course of the winter the ice is always observed to crowd ashore, crumpling up in ridges on the flats and near the edge of the channel. This process was well advanced when his observations were begun, Feb. 6. A row of stakes was planted in the ice, by boring holes through to the water, at distances of about 100 feet apart, avoiding a very near approach to the shore. The distance between the eastern and western stakes was 500 feet. March 18, the easternmost stake had advanced to the eastward 12¾ inches; a stake 200 feet west of this had not sensibly changed its position; the westernmost stake had moved to the westward 12⅙ feet. There was thus a total expansion of the ice of 13 feet 2¾ inches in a breadth of 500 feet,—2.646 per cent., nearly, in 40 days. Of course this motion is entirely independent of the action of gravity, and is possibly due to variations in the temperature of the air, that of the water having been nearly constant. The temperature observed at his house, 120 feet from the river, was as follows: From Feb. 6 to 28 inclusive, mean temperature 22.37° Fahr.; mean of extreme heat each day 32°; mean of extreme cold 12.74°; extreme heat 45°; extreme cold 17°. March 1 to 18 inclusive, mean temperature 33.138°; mean of extreme heat 41.33°; of extreme cold 24.944°; extreme heat 50°; extreme cold 7°. These temperatures are each that of the shade. His observations show that the ice expands without reference to the temperature of the water, and that the temperature of the ice itself varies considerably, its changes having little reference to the water below. It also appears that the rays of the sun at these depths are absorbed largely by an enclosed object, even of a light color. In the uniform temperature of the water, at various depths, there is evidence that the sudden disintegration of the ice, and its disappearance, is not in this instance due to the action of the water. This occurs constantly on the large ponds in the neighborhood, but rarely on the river. It never takes place until the "snow ice" is entirely melted, and is believed to be due to the action of the sun.

AFRICAN TELEGRAPH.

It has been stated in a report to the British Association, that the negro had never shown ingenuity enough to invent letters, symbolic or phonetic. That this is untrue is shown by the "Elliembic" or African telegraph, an instrument which has been in existence for time immemorial to the oldest inhabitant in the Cameroons country, on the west coast of Africa. By the sounds produced on striking this instrument, the natives carry on conversation with

great rapidity, and at several miles distance. The sounds are made to produce a perfect and distinct language, as intelligible to the natives as that uttered by the human voice. The instrument is in universal practice about the Cameroons, and up in the interior, in the Abo and Budi countries, a part of Central Africa not yet visited by Europeans. "In visiting this part of Africa in 1859, my coming was generally announced beforehand to the different villages by the 'Elliembic.' I questioned some of the oldest inhabitants as to the inventor; but none of them could tell me further than that they supposed 'it must have been some of their great-grandfathers.' This 'Elliembic,' therefore (which is a most ingenious invention), must have been in existence in Africa before telegraphs were dreamed of in England." — MR. INNES, *in Athenæum, October*, 1865.

ACOUSTIC PHENOMENA.

Prof. Page, of Washington, to whom we are indebted for the curious observations that a bar, when magnetized, emits a musical sound, has recently published a paper on the cause of the unpleasant jingle sometimes heard in pianofortes and other stringed musical instruments. It frequently happens that an instrument is partly taken to pieces, and searched for some loose screw or fragment of foreign matter which may have fallen on the wires, but without success. Prof. Page shows, however, that, in most cases, the noise is not in the instrument at all, but is really due to the sympathetic vibrations of some object in the apartment, — often a loose pane of glass. He gives an account of a piano, two notes of which had an intolerable jingle. "The room was very small, and while I continued to strike one of these notes, Mr. W. went about the room touching everything with his finger, and at last he touched a pane of glass in the window near the piano, and the jingling ceased at once. On removing his finger it recommenced. On applying the finger-nail very delicately to the pane, it was found to vibrate, and on approaching the ear it was heard distinctly to give out the precise sound of the note on the piano." The pane was wedged up, and search made for the confederate of the other jingling note, which was found to be a loose pane in another window. It often happens that the jingle is transferred to different notes without any apparent cause. This is explained by variations in the tension of the objects in the apartment, caused either by a difference in the temperature, or an alteration in the arrangement of the furniture. This explanation of a very common and very irritating phenomenon appears to us to be extremely ingenious. It may be objected, that the sound cannot come from anywhere else but from the piano; but the ear is remarkably defective in the power of judging of the origin and direction of sounds, as is shown by the extraordinary effects produced by a clever ventriloquist.

Sondhauss ("Pogg. Ann.," March, 1865) details some experiments on the sounds produced by water flowing through orifices in plates cemented at the bottom of upright tubes, in order to compare the resulting musical tones with those produced by a

blast of air under the same circumstances. He found, if the plate was thick in proportion to the diameter of the orifice, no tone could be heard. With small orifices in thin plates, air would produce no sound, while water flowing through the same orifice produced a distinct note. Another difference between the musical capabilities of air and water was, that, by increased pressure, air would produce several successive harmonic tones, while with water the quality only of the tone changed. He found, as Savart had previously, that the sound depended on the tube as well as the orifice. Sondhauss believes that a musical sound can be produced by filling the mouth with water, and squirting it out through a small opening between the lips; but he could not ascertain if any one had ever successfully practiced this desirable accomplishment. He states, in conclusion, that, from the readiness with which sounds are produced by liquids, there is great probability that the depths of the sea are not the silent abodes which we usually suppose. The fish, by squirting out or sucking in water through orifices in their mouths or in their opercula, might readily produce great varieties of tones. The genera Cottus and Trigla, which are known to produce sounds, are probably by no means the only vocal fish; and, in fact, the saying, "Mute as a fish," should be discarded from the company of unimpeachably true proverbs.—*Reader.*

FOG-SIGNAL.

A novel fog-signal has recently been erected on the island of Ushant, near Brest, for the purpose of warning sailors of the proximity of the land during foggy weather. The apparatus consists of a large trumpet fixed vertically on a reservoir of compressed air, supplied by a blowing engine worked by two horses. The bell of the trumpet is bent at right angles, and can be moved horizontally through an angle of 180°, so as to throw the sound in any direction. Communication may be made with the reservoir by means of a stop-cock, so that a continuous or intermittent sound may be produced at pleasure. The sound is so powerful that it may be heard at a distance of three or four nautical miles. It is stated that the authorities intend placing these trumpets on several of the most dangerous parts of the French coast.

NATURE OF SOUND.

At the meeting of the National Academy of Sciences, in 1866, Prof. Henry gave an interesting paper on some recent experiments with fog-bells. The board of officers, which has charge of the lighthouse system, consists of six persons, three of whom are members of this academy. Before the war, they met once a month; but for the last five years they had met every Saturday, to consider various questions of management. They had recently been trying fog-signals at New Haven. A steam-gong, which consisted of two whistles, from fourteen to twenty inches in length, and one foot across, set mouth to mouth, blown by a

steam-engine, had been heard thirty miles. He went to Providence to hear it; and other experiments were tried with trumpets and whistles. Sound was sent with the wind, against the wind, and at right angles with it. Strange to say, it was heard farthest at right angles. Prof. Henry would have been almost afraid to report this last conclusion, but that he afterwards found it had been observed in 1813. These instruments were blown with a definite amount of power and a definite amount of air. The problem was to get most sound with least expenditure of power and air. A trumpet blown by a Roper engine was finally adopted. It seemed probable now that sound was not a mere transfer of vibrations. The body remains at rest, the waves pass by, but a positive effect of some kind seems to be produced. Prof. Henry tried further experiments as to the relative intensity and extension of sound. He strained a delicate test-paper over the mouthpiece of a horn, which received the vibrations at the broad end, and on this he scattered fine sand. It became a test of extreme delicacy. A change of distance as small as a single inch frequently indicated that vibration had wholly ceased. What becomes of the old theory of the propagation of waves of motion or sound if this experiment be conclusive? Prof. Frazer asked if any experiment had been tried on the comparative worth of sounds of a different pitch. A steam-whistle not having been heard in Holland, another was added, the pitch being two octaves and a half apart. No Holland ear could bear the sound! Prof. Henry replied that the steam-gong was constructed in reference to that. The best effect was produced by differences of one-fifth and one-tenth. The thickness of the metal seemed to make no difference. Each whistle was only a resounding cavity.

NEW ACOUSTICAL APPARATUS.

M. Koenig has recently issued a catalogue of acoustic apparatus, in which are figured and described many new instruments that will be highly prized by the lovers of experimental science.

In the first place may be noticed —

Riess' Telephone. — This is an apparatus for the transmission of sound by means of electricity. A light platinum point rests upon a stretched membrane, which, when vibrating, causes the platinum nipple to make and break contact with an adjacent metal band, through which the intermittent current is transmitted to the distant station. There it passes round a bar of soft iron, which, being rapidly magnetized and demagnetized, emits a continuous sound. Thus, a person speaking in Edinburgh can, without any other effort, produce a sound in London.

Seebeck's Syren. — This instrument consists of nine circular metal plates, pierced with holes systematically arranged. By means of powerful clockwork, the disks can be turned, while their velocity of rotation, which can be varied at pleasure, is recorded in the usual manner. The current of air from a bellows is distributed at will, with greater or less intensity, through twelve pipes, which can be fixed in any position before the turning disk.

The different disks are intended to represent different acoustical phenomena, as interference, beats, the harmonics, etc.

Among the instruments is a complete apparatus for resonance. This consists in a series of nineteen hollow copper globes, arranged according to certain notes. Each of the globes is furnished with two openings, one of which establishes a communication with the air, whilst the other is connected with a little tube to be placed in the ear. If any of the harmonics accompanying the fundamental sound contain the proper note, a powerful resonance is heard.

Especially worthy of notice is a large apparatus for the artificial composition of different kinds of sound, by the simultaneous production of a series of simple notes. Eight tuning-forks are fixed vertically between the arms of eight horizontal electro-magnets, round which passes an intermittent current. The interruption in the current is produced by a fork making a certain number of vibrations between the poles of an electro-magnet. In front of each tuning-fork is a resonant tube, the opening into which can be more or less closed by means of a movable stop. When the opening is entirely closed, the tuning-forks can be scarcely heard; but any desired note can be obtained by withdrawing the key which closes the resonant box.

Singing Flames.—There is a pretty modification of one of Count Schaffgotsch's experiments on singing flames. Two little jets of gas issue from two tapering burners. Over the flames are placed two glass tubes nearly in unison. When the flames begin to sing, beats are heard corresponding to the vibratory movement of the flames; a phenomenon first explained by Professor Tyndall, in the "Philosophical Magazine," for July, 1857. So far, the experiment is old; but now M. Koenig causes one of the burners to be rapidly rotated along with a revolving mirror. The broken luminous circle given by the singing flame when unmoved is, when it rotates, changed into a discontinuous crown of light, which appears to be formed of luminous pearls as soon as the flame in the other tube is made to vibrate. By another arrangement, the flames can be made to take the appearance of a double spiral.

Phonautograph.—Hitherto we have mainly trusted to the ear to inform us of the existence of vibrations. M. Koenig now details apparatus by which observations can be made without the use of that organ.

For this purpose, by far the most important instrument is the phonautograph, which writes in the form of a curve not only instrumental notes, but also some of the simpler vocal sounds. Experiments on the phonautograph have recently been made by Mr. Donders, who has sent a preliminary note on the subject to "Poggendorff's Annalen," from which we have obtained the following particulars: The instrument, as used by Mr. Donders, consists in a delicate stretched membrane, to which is attached a light weight, and of a pen for writing the motions of this membrane. The pen employed consists of several elastic tongues springing from a bent holder, and so fixed that the teeth of the

pen rest on the surface of a blackened cylinder which can be caused to rotate. Among other results, Mr. Donders found that, when a simple note was sounded, a simple sinuosity was traced on the rotating cylinder. The form of the curve varies with the pitch of the voice.

A treble voice gives for the same note and the same vowel a simpler curve than a bass voice. The three "sounding" consonants produced almost as simple curves as the vowels, differing slightly, however, from them. Many consonants, which preceded or followed a vowel, produced a characteristic modification at the beginning or at the end of the curve given by the vowel. M. Koenig has also been able to obtain writings of the human voice with his phonautograph, and has traced with correct differences the four notes, *ut, mi, sol, ut;* finally, M. Koenig has succeeded in recording an air, composed on eight notes of the gamut.

After this there is a most elegant apparatus for comparing the vibrations of two sounding columns of air by means of gas flames. This does for organ-pipes what Lissajous' experiments did for tuning-forks; the composition of vibrations in both cases are now rendered visible. Two jets of gas, placed over each other, are made to communicate by branch tubes with the nodal points of two organ-pipes. In front is a turning mirror in which the gas-jets can be viewed. When the two organ-pipes are in perfect unison, the flames appear in the rotating mirror no longer as two parallel series vertically superposed, but are seen to alternate with each other. If the pipes are arranged so as to give beats, the images of the two series will be sometimes superposed and sometimes alternating. If two pipes be taken which sound ut_3 and sol_3, in the mirror two images of one series are seen to correspond with three of the other. By simple arrangements the effects can be varied in a most instructive manner.

In another apparatus, somewhat similar in principle, the quality of a sound can be visibly separated into its elementary notes by means of gas flames. Ten resonant spheres are fixed one over the other, in a series gradually diminishing in size. Each communicates by a tube with a box, which forms a pressure case, and from which spring ten jets of gas, also placed in a line one over the other. A revolving mirror parallel to this line shows which flames are put in vibration by the resonant globes; the flames in communication with the spheres in which there is no resonance appearing simply as a line of light.

An apparatus for the study of the simple and composite vibratory movement in cords was suggested by M. Melde, in "Poggendorff's Annalen." This, as made by M. Koenig, is as follows: A cord is stretched between two tuning-forks, which are fixed upon an upright support. When the forks are caused to vibrate, the cord will be observed to show the co-existence of the harmonics with the fundamental note, or the co-existence of two harmonics. The beats can also be shown, either with the fundamenal note or with one of its harmonics. By simply varying the tension of the cord, and using different tuning-forks, an immense number of vibratory forms can be produced at pleasure. With this inter-

esting apparatus, other simple experiments can also be executed. — *Reader.*

FALL OF RAIN.

The last weekly return of the Registrar-General gives the following interesting information in respect to rain-fall: "Rain fell in London to the amount of 0.43 inch, which is equivalent to 43 tons of rain per acre. An English acre consists of 6,272,640 square inches; and an inch deep of rain on an acre yields 6,272,640 cubic inches of water, which, at 277,274 cubic inches to the gallon, makes 22,622.5 gallons; and as a gallon of distilled water weighs 10 lbs., the rain-fall on an acre is 226,225 lbs. avoirdupois; consequently an inch deep of rain weighs 100.99 tons, or nearly 101 tons per acre. For every 100th of an inch, a ton of water falls per acre." If any agriculturist were to try the experiment of distributing artificially that which nature so bountifully supplies, he would soon feel inclined to "rest and be thankful."

M. Petit, the director of the Observatory at Toulouse, speaking of the late heavy rains, says: "The quantity is not so unusual as at first sight would appear. The average annual fall is about 60 centimetres, rather more than 2 feet English, spread over about 100 rainy days, thus giving an average fall of about 6 millimetres for each day, or about 6 litres, 10 to 11 pints English, per square metre. The average of the heavy rains of the 15th, 16th, and 17th of January, in the present year, rose to about 9 millimetres. Greater falls have often occurred in France. On the 19th of September, 1844, 35 millimetres of rain fell at Toulouse in 30 minutes; and on the 10th of August, 1859, there fell 59 millimetres in two successive storms of about 40 minutes each in duration. In recalling the impression of terror created by the sight of a precipice, one is inclined to ask how it is that we are not terrified at such enormous quantities of water being suspended over our heads. But the question appears under a still more extraordinary aspect, when we consider the amount of heat required to vaporize all the water which we receive in the form of rain. When we remember that in the tropics there fall about 2 metres of water per annum, that in our climate we have never less than 50 or 60 centimetres, and that the masses of snow in the polar regions must also furnish a great quantity of water, it will be readily admitted that the annual rain-fall must be, at least, equal to a stratum of water all over the globe of 50 centimetres, upwards of 19½ inches English. It is easy, with these facts given, to see that the evaporation caused by the heat of the sun must render to the atmosphere about 175,000,000,000 cubic metres of water per day, or rather more than 2,000,000,000 of litres a second. And yet the furnace is 38 millions of leagues distant from us." — *Journal of the Soc. of Arts, Nos.*, 639, 640, 1865.

CHEMICAL SCIENCE.

ISOMERISM.

Berthelot, in a memoir on a new kind of isomerism, proposes the following subdivision of this subject: Isomeric bodies — that is to say, bodies formed of the same elements united in the same proportion — can be separated into a certain number of classes or general groups: —

1. *Equivalent composition.* — Substances which appear to have a purely accidental relation to each other; for instance, butyric acid, $C_8\,H_8\,O_4$, and dialdehyde $(C_4\,H_4\,O_2)_2$.

2. *Metamerism.* — Bodies formed by the union of two distinct principles, so that in their formulæ a kind of compensation is established; for example, methylacetic ether, $C_2\,H_2\,(C_4\,H_4\,O_4)$, and ethylformic ether, $C_4\,H_4\,(C_2\,H_2\,O_4)$.

3. *Polymerism.* — Compounds arising from the union of several molecules to form one; this is shown in the case of amylene $(C_{10}\,H_{10})$ and diamylene $(C_{10}\,H_{10})_2$.

4. *Isomerism, properly so called.* — There are bodies that, differing in their properties, retain these distinctive features in their passage through certain compounds, the properties of which result from the internal structure of the compound molecule taken as a whole, rather than the diversity of the components which have produced it. This is observed in the cases of essence of terebenthine and citron, the sugars, the symmetrical tartaric acids, and the two classes of ethyl-sulphates.

5. *Physical Isomerism.* — By which is meant the different states of one and the same body, the diverse nature of which vanishes when the substance enters into combination. To these five classes, Berthelot proposes to append a new one, called kenomerism, distinct from all the others, though allied to metamerism.

6. *Kenomerism.* — Two different compounds may lose, by the effect of certain reagents which bring about decomposition, different groups of elements, and the remainders be identical in composition; these two derivatives, however, may yet be distinct the one from the other, both in physical and chemical properties. They retain to some extent the structure of the compounds from which they take their origin. To take examples: alcohol, by losing 2 equivalents of hydrogen, is turned into aldehyde: —

$$C_4\,H_6\,O_2 - H_2 = C_4\,H_4\,O_2.$$

Glycol, on the other hand, by giving up 2 equivalents of water, is converted into glycolic ether (oxide of ethylene): —

$$C_4\,H_6\,O_4 - H_2\,O_2 = C_4\,H_4\,O_2.$$

Glycolic ether and aldehyde are isomeric; their composition is

the same, but their properties, both physical and chemical, are extremely different. This is a good case of kenomerism. Again, essence of terebenthine combines with hydrochloric acid under different conditions to form two distinct hydrochlorates, the monohydrochlorate, $C_{20} H_{16} H Cl$, and the dihyodrochlorate, $C_{20} H_{16} 2 H Cl$. From the first body the crystalline compound $C_{20} H_{16}$, camphene, is obtained, and from the latter $C_{20} H_{16}$, terpilene two hydrocarbons of very different properties. — *Reader.*

MECHANICAL ENERGY OF CHEMICAL ACTIONS.

A suggestive paper, by Dr. Van der Kolk, on the mechanical energy of chemical actions, appeared in "Poggendorff's Annalen" some time since. Mr. Foster gives a translation of this paper, adding some critical notes in the April number of the "Philosophical Magazine." Dr. Van der Kolk endeavors to show that there is a connection between the experiments of Deville on dissociation, and those of Favre and Silbermann on evolution, and, in a few cases, absorption, of heat by chemical combination. Starting from the point that every substance raised to a certain temperature above zero has received a given amount of heat, or, as termed by Thomson, contains a definite quantity of energy, the author proceeds to examine the different cases presented in chemical union, when the body, after combination, possesses either more or less energy than its constituents. He thus arrives at the following law: Bodies which evolve heat, when decomposed by elevation of temperature, are not reproduced by subsequent cooling. Interesting examples confirming this law are quoted from Favre and Silbermann's results, from which a second theorem is established, namely, that when a body on heating passes from one condition to another with evolution of heat, it does not return to its first condition upon subsequent cooling; plastic sulphur, barley-sugar, phosphorus, etc., follow this law. The converse to this theorem, though not proved, yet is shown to be frequently confirmed. From these laws it is stated that, in order to produce a chemical compound, not only must there be the chemical force or affinity sufficient for combination, but there must also exist the necessary energy. To illustrate this, examples are adduced of phenomena which have hitherto stood as enigmas in chemical science. Thus the electric spark, it is known, can cause the combination of an unlimited quantity of some gases, as, *e. g.*, oxygen and hydrogen, whilst other gaseous mixtures can only be gradually combined along the path of the spark itself, as, *e. g.*, nitrogen and oxygen. In the first case, the energy of the constituents exceeds that of the compound; combination of the mass therefore occurs as soon as the power of affinity is increased by the spark; the union of a few atoms of hydrogen and oxygen developing sufficient heat to cause others to combine, and thus of the rest. In the second case, however, as the energy of the constituents is less than that of the compound, the electric spark has not only to increase the affinity, but at the same time to add the needful energy. Hence, as no heat is evolved by the

union of a few atoms of nitrogen and oxygen, the combination cannot extend throughout the mass, but occurs only along the line of the spark, which, in this case, has to increase both affinity and energy.

IS NITROGEN AN ELEMENT?

Chemistry and astronomy at the present day seem to be twin sisters in science, as their independently obtained results remarkably confirm each other in many recent instances. A late example of this is in reference to the constitution of nitrogen, and is afforded by Mr. Huggins' observations of the spectra of some of the nebulæ, taken in connection with observations of the nitrogen spectrum made in the laboratory of Mr. Waltenhofen. Both these observers have been led to the suspicion that nitrogen is not an elementary substance, but a compound of more simple forms of matter, — the former, by observing in the spectra of some of the nebulæ some, but not all, of the lines of the nitrogen spectrum, as if nitrogen were a compound body, and those nebulæ contained, among the materials of which they are composed, one of its constituents and not the other; and the latter, by the discovery that, in a highly rarified nitrogen atmosphere the violet rays disappear before the blue and green rays. — *Mechanics' Magazine, Oct.*, 1865.

Mr. Henry Kilgour, of Edinburgh, maintains that nitrogen is carbonic oxide in an allotropic state, having had its activity diminished by heat, electricity, or some other force at present unknown. His chief points are that carbonic oxide and nitrogen have exactly the same atomic weight and atomic volume, and very nearly the same specific gravity and specific heat; that both are neutral, and capable in only a very few instances of entering directly into combination with other bodies; that neither of them has either color, taste, or odor, or can support combustion or respiration, or can combine with acids to form salts, but that both can combine with oxygen to form acids. He draws many other equally striking parallels, for which see *Mechanics' Magazine, Nov.*, 1865.

DISSOCIATION OF GASES AT HIGH TEMPERATURES.

Some interesting researches on this subject have recently been made by M. L. Cailletet, in developing the discovery of M. St. ClaireDeville, that at a high temperature the constituents contained in a mixture of gases will separate. As it is necessary to cool the dissociated elements rapidly, it was necessary to devise an apparatus suited to the purpose. By means of this apparatus some important facts were observed. Thus, that oxygen has no action whatever on hydrogen, carbon, or carbonic oxide, placed within a mass which is at a temperature higher than the melting point of platinum; and the conclusion arrived at was, that all bodies would most probably be dissociated by a temperature sufficiently high. — *Intellectual Observer*, 1866.

REDUCTION OF ALUMINIUM BY ZINC.

The largest item of the cost of aluminium has hitherto been that of the sodium used in its reduction; but we are now told that M. Basset, of Paris, has succeeded in reducing it from the chloride by means of the much cheaper metal, zinc. His plan is to fuse chloride of aluminium with an excess of zinc, and he states that the results are chloride of zinc and an alloy of zinc and aluminium, from which all the zinc may be driven off by a white heat. If this process be practicable on the large scale, there will be no reason why aluminium should not speedily become cheap enough for employment in the many mechanical applications for which it is so admirably fitted, instead of being confined, as at present, to ornamental uses only. — *Mech. Mag., Jan.*, 1865.

INGREDIENTS OF ATMOSPHERIC AIR.

H. Reinsch stretched eighteen square feet of carefully washed linen cloth upon poles, so as to form a sort of roof. Over one such roof he allowed very dilute hydrochloric acid to trickle for fourteen days, and over another a one-per-cent. soda solution for the same time. The collected liquors were then evaporated and examined. The acid liquor was first distilled. A beautiful violet-colored (an aniline?) compound passed over first, then sal ammoniac, and, last, some pyrogenous products arising from the organic substances absorbed by the acid. The residue was then completely carbonized, and the ash examined. It contained traces of metals precipitable by H_2S (Pb, Sn, or Cu?). The aqueous extract of the ash contained Na, considerable traces of Ca and K, and doubtful traces of Mg. The hydrochloric solution of the ash contained Ca, Fe, Mn, Al, and traces of SO_3. Silica remained behind insoluble. In the collected soda liquor the author found much Cl and CO_2, with decided traces of PO_5 and SO_3. There were also traces of Ca, and much organic matter, with Fe, Mn, and SiO_2.—*N. Jahrb. f. Pharm.*, 24, 193.

CRYSTALLOGENIC FORCE.

According to M. Kuhlmann's researches on the Crystallogenic Force,—on the artificial crystallization of mineral substances and of metals by humid means, — when crystals of carbonate of soda were placed in a solution of sulphate of copper, a layer of carbonate of copper was precipitated on them; by degrees the whole of the carbonate of soda changed into a solution of sulphate of soda, whilst the slowly-formed crystals of carbonate of copper produced artificial minerals, closely resembling azurite and malachite. In the same way, crystals of carbonate of soda placed in a solution of sulphate of nickel formed blue and green carbonate of nickel, and placed in a solution of nitrate of cobalt produced magnificent ruby-red crystals of carbonate of cobalt. The author states that the reduction of metals to the crystalline state can be produced by the action of water and acids; especially is this the case with alloys, and he shows that a lead alloy can thus be crystallized. Sulphate of copper placed in a solution of polysulphide of potassium

became covered with sulphide of copper, upon which were deposited fine rhombohedric crystals of sulphur. Gold has been produced in the form of a beautiful crystalline gold-sand, by placing chloride of gold, contained in a porous vessel, in the midst of a solution either of sulphate of iron, hyposulphite of soda, or oxalic acid. M. Kuhlmann then mentions another remarkable result he obtained, by placing crystals of sulphate of copper in a solution of monosulphide of potassium, and concludes by showing that wood has a true deoxidizing effect upon the salts of copper and iron, transforming the sulphates into sulphides.

SEDIMENTS OF WINES.

M. Pasteur states that he has carefully examined these sediments, and has found they can all be classed under three heads. The first are crystals of bitartrate of potash, neutral tartrate of soda, or a mixture of the two salts. These adhere to the sides of the bottles, and have but little influence upon the composition and quality of the wine. The second kind, also covering the sides of the bottles, are brown coloring matters, which, originally dissolved in the wine, are gradually rendered insoluble by oxidation. This sediment, therefore, is caused by the presence of oxygen existing in the air which is over or dissolved in the wine. By several experiments upon different wines enclosed in tubes, the author proves this fact, and shows that the deposit takes place more rapidly when the tubes are exposed to the light. The wine becomes of a lighter color, and acquires the peculiar odor and flavor of old wines which have returned from a voyage. He attributes the good effect of a tropical voyage upon wine, not, as has been recently supposed, to the increase of temperature, but to the continual changing of the vitiated air over the wine through variations in the pressure from constant shaking and evaporation. Accordingly, wines hermetically sealed in bottles without oxygen have no sediment; indeed, do not sensibly change in any way. The third class of sediment, by far the most injurious, is composed of various cryptogamic vegetations, which, acting as ferments, are the sole cause of the "diseases" of wine. The author infers that wines would be improved by leaving them in the cask until ripe, and then bottling them.

UTILIZATION OF SEWAGE.

At the meeting of the London Chemical Society, February 1, 1866, Dr. Gilbert read a lecture "On the Composition, Value, and Utilization of Town Sewage," of which the following were the conclusions: 1. It is only by the liberal use of water, that the refuse matters of large populations can be removed from their dwellings without nuisance and injury to health. 2. That the discharge of town sewage into rivers renders them unfit as a water-supply to other towns, is destructive to fish, causes deposits which injure the channel, and emanations which are injurious to health, and is also a great waste of manurial matter. 3. That the proper mode of both purifying and utilizing sewage-water is to apply it to land. 4. That, considering the great dilution, con-

stant daily supply, greater amount in wet weather, and cost of distribution, it is best fitted for application to grass, although it may be occasionally applied to other crops under favorable circumstances. 5. That the direct result of the general application of town sewage to grass-land would be an enormous increase in the production of milk (butter and cheese) and meat, whilst by the consumption of the grass a large amount of solid manure, applicable to arable land and crops generally, would be produced.

METHOD OF OBTAINING THE ODORIFEROUS PRINCIPLES OF FLOWERS.

The means used hitherto for obtaining the odorous elements of flowers are troublesome and more or less wasteful. A volatile essential oil, obtained from well-purified Pennsylvania petroleum, and termed petroleum ether, is now used very successfully for this purpose. It absorbs the odorous principle of the flowers, new quantities of which are added continually to it, until it becomes saturated. It is then separated from the odorous principle by evaporation, but little of it being lost. The fatty and other matters associated with the perfume, which is left behind, may be separated from it by means of alcohol, in which they are nearly insoluble, but which dissolves the odorous principle with great facility. This method may be used for extracting any aroma, especially when contained in flowers. — *Intellectual Observer, April*, 1866.

PROCESS FOR STAINING WOOD.

In the "Journal of the Franklin Institute" for November, 1866, is described the process of Barton H. Jenks for staining woods. The wood to be treated is placed in a close vessel, which is connected with an air-pump, and the air is removed. The coloring fluid is then allowed to enter and permeate the wood, which it does in a very thorough and even manner, on account of the removal of all air from the fibre. The excess of fluid is then pumped out, or the wood is removed and allowed to dry in the usual way. Specimens of white pine were stained with the following substances: —

1.	Nitrate of iron	Warm gray, light.
2.	Nitrate of iron and paraffin	Warm gray, dark.
3.	Sulphate of iron	Colder gray, light.
4.	Sulphate of iron and paraffin	Cold gray, dark.
5.	Sulphate of iron and logwood	Like 3.
6.	Sulphate of iron, logwood, and paraffin	Like 2.
7.	Chromate of potash	Yellow gray, light.
8.	Chromate of potash and paraffin	Yellow gray, dark.
9.	Bichromate of potash	Yellow gray, between 7 and 8.
10.	Bichromate of potash and paraffin	Very rich yellow gray.
11.	Logwood	Light orange.
12.	Logwood and paraffin	Dark orange.
13.	Aniline blue	Bluish slate.
14.	Aniline blue and paraffin	Bluish slate, dark.
15.	Aniline red	Violet, with yellow shade.
16.	Aniline red and paraffin	A little darker than 15.
17.	Aniline solferino	Rich purple.
18.	Aniline solferino and paraffin	Rich purple, darker.

SPONTANEOUS COMBUSTION OF PYROTECHNICAL COMPOUNDS.

The following are extracts from a communication of Mr. Thomas Arnall to the "London Pharmaceutical Journal," of September, 1866: "The compositions which are liable to this spontaneous action all contain chlorate of potash and sulphur, with nitrates of strontia and baryta, oxide of copper, etc., as coloring agents. The cause of this action I believe to be, in most cases, acidity, either of the sulphur or some other ingredient used. It is well known that most of the flour of sulphur, as met with in commerce, has a slightly acid taste. This acidity has been attributed to atmospheric oxidation from long exposure, but more probably is caused by partial combustion during sublimation. Now, supposing sulphur containing a slight trace of sulphuric acid to be mixed with chlorate of potash, it will liberate a corresponding quantity of chloric acid; this at once oxidizes more sulphur, and so the mutual reaction goes on until the mixture ignites. But we have also nitric acid in combination, and the nearly anhydrous vapors of these two acids will sufficiently account for the heating and ignition of the compounds in which they are evolved.

"I have been informed by practical pyrotechnists that they never use sublimed sulphur, but buy it in roll, and powder it for use when wanted; and I believe that latterly the sulphur has been superseded for indoor uses by a mixture of shellac and resin. This has the merit of comparative safety, although the brilliancy of the colors will not bear comparison with those formulæ where sulphur is used.

"These remarks do not apply to a most dangerous compound for purple fire, which contains chlorate of potash, sulphur, nitrate of strontia, and anhydrous sulphate of copper. Although the color is exceedingly beautiful, I can enumerate five deaths from explosions, in addition to other cases not fatal, where this formula was in use; and I have had it ignite four times in my own experiments. In this case no acidity of the ingredients seems requisite.

"I am disposed to attribute the ignition, first, to the anhydrous sulphate of copper attracting moisture from the air; next, to double decomposition of the copper salt and chlorate, ultimately forming chloride of copper (possibly bichloride), with evolution of chloric oxides or chloric acid. I have substituted black oxide of copper for the sulphate, and the mixture has not shown any tendency to ignition.

"I believe that disaster may be frequently averted by first mixing a few drachms of the ingredients in a mortar. If the ingredients are pure, no smell should be perceived; but if acid be contained either in the sulphur or other ingredients, a peculiar, somewhat ozonic odor will arise, which may be considered as indicative of danger."

SPONTANEOUS COMBUSTION OF COAL ON BOARD SHIPS.

The committee of Lloyd's Salvage Association has issued the subjoined report upon this subject, which has caused the destruction of so many vessels: —

There are a great many opinions afloat relative to the cause of spontaneous combustion, some ascribing it to the chemical composition of the coal, others to the absence of ventilation, either natural or artificial, while others, again, consider it is caused by moisture.

1. As to the chemical composition of coal. Owners know that one kind of coal is more liable to heat than another, and some will not ship that which is dangerous; but others are less scrupulous, and ship all kinds. This might be partially checked by obliging owners to deposit at the Customs an analysis of the coals sent by them; they would be afraid of having any fire traced to their coal. But a better method is suggested by Mr. R. Hunt, F.R.S., of the Museum of Practical Geology, in England. A machine has for some time been employed for washing away the iron pyrites, or bisulphuret of iron, from the small coal at the pit's mouth, previous to converting it into coke. While the coal is in transit, the oxygen acts upon the bisulphuret of iron, and evolves great heat; consequently, if the iron pyrites were excluded, a great source of danger would be obviated. The cost is only about sixpence a ton for the washing, and would be amply set off by the lower rate of insurance consequent on greater security.

2. As to natural ventilation. It is chiefly small coal which heats; there being room in large kinds for the air to circulate between the lumps; but as the Chilian consumer requires small coal for smelting purposes, the only remedy is for shippers to send as large coal as can be used.

3. Artificial ventilation. Mr. Hunt proposes a method of securing this; but its efficacy has not yet been proved. It is to let down a pipe in the after part of the ship well into the coal, and to let down one in the fore part, with the top communicating with the chimney of the cook's galley; this would produce an up draught, and keep down the temperature of the coal.

4. Moisture. Coals are in every way liable to get wet. At the pit's mouth they lie uncovered; in the wagons they are not in any way protected, the expense of tarpaulins being too great. While being shipped, the hold is open to the weather; and at sea the hatches are frequently taken off, and the spray and sea air must necessarily dampen them.

On the whole, the committee commended to those connected with shipping coal —

That coal of undue fineness or damp coal should not be shipped.

That a rod similar to those used in British ships should be used every twelve or twenty-four hours, to ascertain the temperature of the coal.

That the proposition of Mr. Hunt for artificial ventilation should be tried.

That the coal should be washed previous to shipping. — *Scientific American.*

PROTECTION OF VESSELS' HULLS.

The Jouvin composition for protecting the hulls of ships has been tried on the French armor-plated vessel, the "Helene," which

was launched in December, 1863. Previous to that, her hull was covered with two coats of paint, the base of which consisted of metallic zinc in powder, and then with minium paint containing ten per cent. of M. Jouvin's poisonous composition. After remaining fifteen months in the water, she was placed in the dry dock, when her hull was found to be covered with a gray, mud-like matter, to the surface of which a few mussels had attached themselves by their byssus, thus being isolated from immediate contact with the poisonous composition. A slight touch was sufficient to detach them. They were principally collected on the spots at which the struts had been fixed, which were only painted a few moments before the vessel was launched. There were no marine plants, and no barnacles. These results seem to be highly satisfactory, since neither plants nor mollusks can attach themselves, and the bottom may be cleaned by brushes, or even by rubbing with a piece of wood, without the necessity for scraping.

SULPHURETTED HYDROGEN.

This gas, which, for experimental purposes, is usually obtained by means of sulphuret of iron, may be procured more conveniently, and in a state of great purity, by the use of sulphuret of calcium. The latter is formed very easily by mixing uncalcined powdered gypsum with one-fourth of its weight of calcined gypsum, and powdered pit coal equal to one-third of the whole of the gypsum used, and working up the mixture to a stiff dough with water; next forming it into pieces four inches long, two wide, and one and a-half thick, sprinkling them with powdered coal, and drying them; then placing them with coke in a wind furnace, and keeping them at a very high temperature for two hours. When cold, they will be found, externally, to consist of oxysulphuret of calcium; but, internally, of pure peach-colored sulphuret of calcium, which may be broken in pieces about the size of nuts, and preserved in well-stoppered glass bottles. If water is added to these, and then sulphuric acid in small quantities at a time, sulphuretted hydrogen is given off with great uniformity. — *Scientific Review.*

ACTION OF SEA-WATER UPON METALS.

In a paper by Messrs. Calvert and Johnson, in the London "Mechanics' Magazine" for March, 1865, are given the results of experiments in which twenty square centimetres of various metals, carefully cleaned, were immersed in equal volumes of sea-water for the space of one month; the conclusions are as follows: 1. That the metal now most in vogue for shipbuilding, namely, iron, is that which is most readily attacked. 2. That this is most materially preserved from the action of sea-water when coated with zinc, and, therefore, in our opinion, it would amply repay shipbuilders to use galvanized iron as a substitute for that metal itself. The above facts fully confirm those published in a previous paper, in which it was shown that when iron was in contact with oak they mutually acted upon each other,

producing a rapid destruction of the two materials, whilst little or no action took place between galvanized iron and the wood. 3. The extraordinary resistance which lead offers to the action of sea-water naturally suggests its use as a preservative to iron vessels against the destructive action of that element; and, although we are aware that pure lead is too soft to withstand the wear and tear which ships' bottoms are subject to, still we feel that an alloy of lead could be devised which would meet the requirements of shipbuilders. These results are yet more remarkable when the metals are exposed to a strong tide and a rough sea. Sea-water acts very differently upon different brasses, according to the existence in them of a very small proportion of another metal; thus, in pure brass the zinc is most rapidly dissolved (the contrary to what takes place in galvanized iron), whilst it acts as a preservative to the copper. Tin, on the other hand, appears to preserve the zinc, but to assist the action of sea-water upon the copper. The great difference between the action of sea-water upon pure copper and upon Muntz metal seems to be due not only to the fact that copper is alloyed to zinc, but to the small proportion of lead and iron which that alloy contains; and there can be no doubt that shipbuilders derive great benefit by using it for the keels of their vessels. An alloy of lead, tin, and antimony has been found by Mr. J. Robinson to resist the action of sea-water better than any other metal or alloy.

COMPARATIVE ANALYSIS OF THE WATERS OF THE DEAD SEA AND THE RED SEA.

The Water of the Dead Sea. — The Duc de Luynes has recently found fishes in the southern portion of the Dead Sea, around the ruins of Sodom, apparently multiplying their species comfortably. M. Daubrée has analyzed several specimens of the water from various localities and at different depths, and has presented his results to the Academy of Sciences of Paris, as follows: —

1. The density of the Dead Sea increases with the depth.

2. The composition of the water is not identical throughout its extent, even when those localities near the mouth of the river and the small streams which enter it are excepted. The water taken five miles to the east of Ouadi Mrabba contains four times more lime than that taken five miles east of the Ras Feschkah; but the latter contains twice as much sodium as the former.

3. The concentration of the water is also very variable in different localities.

4. The water collected to the north of Sodom, in the part which forms a lagoon, contains more chloride of sodium than chloride of magnesium, which is the reverse of the ordinary character of the waters of the Dead Sea, and explains the possibility of fishes living there.

5. The proportion of the saline matters remains the same at all depths; except that the bromides appear to concentrate at depths of 300 metres.

6. The water of the Dead Sea appears to contain no iodine nor phosphoric acid.

7. The spectroscope detects in the dried salts neither lithium, calcium, nor rubidium. They contain but little sulphuric acid; but are composed almost exclusively of chloride of magnesium, sodium, calcium, and potassium, and of a certain quantity of the bromides of these bases. Their relative richness in bromine and potassa is such as to deserve the attention of manufacturers of these articles.

8. The waters of the rivers and springs around the Dead Sea are composed of chlorides, sulphates, and carbonates of lime, magnesia, soda, and potassa, and contain no bromine appreciable to analysis.

Water of the Red Sea.—MM. Robinet and Lefort have just submitted to the Academy of Sciences of Paris an analysis of the water of the Red Sea. It shows that in a litre there are 45.38 grammes of fixed salts, of which 30.30 are chloride of sodium, 2.88 chloride of potassium, 4.04 chloride of magnesium, .06435 bromide of sodium, 1.79 sulphate of calcium, and 2.74 sulphate of magnesium. Except in being a little more intensely saline, the composition of the water of the Red Sea is thus just the same as that of average sea-water, but very different indeed from that of the Dead Sea, so that this analysis quite disproves the hypothesis that between the Dead Sea and the Red Sea there exists a subterraneous communication.

The following table, by MM. Robinet and Lefort, from the "Comptes Rendus," gives the percentage composition of the residue obtained by evaporation from the waters of the Mediterranean, Red Sea, and Dead Sea:—

	Mediterranean.	*Red Sea.*	*Dead Sea.*
Chlorine	52.92	50.33	65.78
Bromine	1.14	1.11	1.25
Sodium	31.15	30.92	11.22
Potassium	7.00	3.33	3.71
Calcium	1.18	1.16	5.67
Magnesium	3.62	3.54	12.59
Sulphuric Acid	6.42	6.35	1.05

From this we perceive that while the Mediterranean has a much larger quantity of potassium than either of the others, and both it and the Red Sea have nearly three times as much sodium as the Dead Sea, the latter has more chlorine, more calcium, more magnesium, and less sulphuric acid than either of the former.

AN ADVANTAGEOUS METHOD OF PREPARING OXYGEN.

Fleitmann's method of preparing oxygen from bleaching-powder depends on the complete decomposition of a concentrated solution of hypochlorite of lime, when warmed, with a trace of freshly-prepared moist hyperoxide of cobalt, into oxygen and a solution of chloride of calcium; no chlorate of lime is formed, and the whole of the active oxygen is given off, at a temperature of 70° to 80° C., in a regular current, with a gentle foaming of the liquid. His explanation of the process is that a lower hyper-

oxide constantly takes oxygen from the hypochlorite of lime, and passes into a higher oxide, which is decomposed into oxygen and the lower oxide, and the process is then repeated. One-half to one-tenth of one per cent. of hyperoxide is sufficient to decompose an indefinite amount of the hypochlorite. According to him, the advantages of this method are: 1. The evolution of the gas is very regular and easily managed, so that the process may be used for lecture experiments in which a gas bladder cannot be employed. After the heat is once applied, the lamp may usually be removed, the decomposition going on to the end. 2. All the oxygen of the material is obtained, which is not the case when peroxide of manganese is heated. 3. It is much cheaper than that by means of chlorate of potash.—*Ann. der Chemie und Phar.*, 134, 64.

OXYGEN OBTAINED FROM ATMOSPHERIC AIR.

Our ordinary modes of obtaining oxygen, for experimental and other purposes, are very costly or very troublesome. It may, however, be procured with great facility through the medium of permanganate of soda, which, as it may be used over and over again for the purpose, will entail but a trifling expense. Atmospheric air is passed over a solution of the permanganate, which, after a while, becomes saturated with the oxygen it has absorbed, the nitrogen having passed off. To separate the oxygen from the solution, a current of vapor at a proper temperature is substituted for the current of air; this, almost without producing any change in the permanganate solution, further than dilution, causes the oxygen to be evolved. Concentrating the solution by heat renders it again fit for use, especially if a very small quantity of the permanganate is added to it. —*Intel. Observer*, 1866.

JAPANESE HAND FIREWORKS.

Dr. Hoffmann lately exhibited to the London Chemical Society some small paper fuses brought from Japan. They burn with a small, scarcely luminous flame, a red-hot ball of glowing saline matter accumulating as the combustion proceeds. When about half of the fuse is consumed, the glowing head begins to send forth a succession of splendid sparks, assuming the character of a brilliant scintillation very similar to that observed in burning a steel spring in oxygen, only much more delicate, the individual sparks branching out in beautiful dendritic ramifications. His first idea was to look for a finely-divided metal in the mixture; but examination in the laboratory showed that it was quite free from metallic constituents, and contained only carbon, sulphur, and nitre; these were present in the following proportions: carbon, 17.32; sulphur, 29.14; nitre, 53.64. Each fuse contained about 40 milligrammes of the mixture, folded up in fine paper. He had easily imitated them. A mixture of carbon, 1 (powdered wood charcoal), sulphur $1\frac{1}{2}$, and nitre $3\frac{1}{4}$, produced the phenomenon in even a more striking manner. Ordinary English tissue paper might be used, but the genuine Japanese paper was far better.

COLORATION OF GLASS.

M. Pelouze having observed that the glasses of commerce were colored yellow by carbon, sulphur, silica, boron, phosphorus, aluminium, and even by hydrogen, was led to make a series of experiments for ascertaining the cause of the identity of the results with such different reagents. His conclusions, verified beyond a doubt, have a considerable importance in reference to the possible perfection of glass manufacture. His first conclusion is, that "all the glasses of commerce contain sulphates." These salts (sulphates of soda, potassa, or lime) render the glass more or less alterable by atmospheric agency, and come into the glass from two sources, either directly from the use of these sulphates as a flux, or from the presence of the sulphate of soda as an impurity in the commercial carbonate. The effect of their existence may be seen by examining many of the panes of glass in our windows, which have been for some years exposed to the air, when the surface of the glass will be found to be corroded and partially opaque like ground glass, and by examination under a magnifier will be found to be covered with crystals. He found these sulphates present from one to three per cent. in all the commercial glasses, window, plate, table, bottle, and Bohemian glass; he also found two per cent. of sulphate of soda in a glass from Pompeii. The coloration is now easily explained; the reagents named above reduce the sulphates and produce an alkaline sulphuret, which has the property of giving the yellow color. He proved this by showing, first, that when the glass materials were carefully purified from sulphates, no color was produced by carbon, hydrogen, boron, silicon, phosphorus, or aluminium; and, secondly, that an alkaline sulphuret added to the pure materials produced the color. —*Acad. des Sciences, Paris*, 1865.

CHEMICAL CONSTITUTION OF THE BRAIN.

Liebreich has discovered in the fresh brain of man and animals a crystalline substance which he has called protagon. After freeing it from blood and membranes, the brain should be rubbed in a mortar to a fine paste, and the mass agitated in a flask with water and ether. Cholesterine and soluble substances being thus removed, after filtering, the mass is treated with 85 per cent. alcohol at 45° C. in a water bath, and then filtered through a water-bath filter. The filtrate being cooled to 0° C., an abundant flocculent precipitate falls, which must be filtered and washed with cold ether to free it from cholesterine; the mass being then dried under an air-pump over sulphuric acid, moistened with a little water and dissolved in alcohol at 45° C., the solution, after filtration, is to be cooled gradually upon a water bath to the mean temperature of the air, when it will be found filled with microscopic crystals, —these differ somewhat in form according to the quantity of alcohol used. The pure protagon thus obtained was found to have the formula $C_{232} H_{241} N_4 PO_{44}$. Dried, it is a light flocculent powder, soluble in hot alcohol and ether, but with difficulty in cold.

It possesses a very complex structure, and its products of decomposition separate it remarkably from other known substances. He considers that the glycerin-phosphoric and oleo-phosphoric acids, cerebrin, etc., of the books are secondary products of the decomposition of protagon. —*Ann. der Chemie und Pharm.*, 134. 29.

CHEMICAL ACTION OF THE PANCREATIC JUICE.

The study of the function performed by the pancreatic secretion in the animal economy has led to the discovery of properties possessed by it, which, in a chemical point of view, are of great interest. In ordinary circumstances, fat is incapable of mixing with water. After having been heated along with that fluid, it will separate perfectly from it, even before cooling. Such is not the case if it has been previously heated with fresh and acid pancreatic juice. It will then form an emulsion by mere mixture with water, a circumstance which is remarkable, as its constitution has undergone no change that our present chemical knowledge will enable us to detect. That a change has taken place in it is, however, certain; and it is equally certain that this change is not saponification, as the fat globules remain perfectly distinct, and of nearly uniform size. The researches of chemists will, no doubt, ultimately throw light on the circumstance, which may lead to important results in more departments than one of practical science. —*Intellectual Observer*, 1866.

PROTECTION OF IRON.

It has been ascertained that sheet-iron may be protected from oxidation by coating it with a thin fused layer of magnetic oxide. For this purpose it is embedded in hæmatite, or some other native oxide of iron, reduced to a fine powder, and kept for several hours at a red heat, and then is allowed to cool gradually. The black coating produced in the same way by a combination of the oxides of zinc and iron is probably still more effective. It may be found very advantageous to cover in this way the iron used in shipbuilding.

DISINFECTANTS.

As an illustration of the want of general knowledge of the laws of disinfection, and of combined action between local authorities, the author said he might refer to what is being done in London. The drainage of 1000 acres, saturated with a powerfully oxydizing disinfectant, mingles in the sewers with that of another 1000 acres, to which a powerfully deoxydizing agent has been applied. The result is, that an enormous amount of money is expended with but very inadequate results, and many valuable agents may fall into discredit from the want of discrimination in their application. Disinfectants of great value are being used for purposes for which they are totally unfit; useful, but incompatible, disinfectants are recommended in the same paper of instructions, and chemicals of the most potent description are given to ignorant

persons without warning as to their application. The best plan of disinfection should, therefore, be definitely settled, and its adoption made uniform. Disinfectants should always supplement each other, so as to pervade the whole mass on the meeting of the contents of various sewers. The opposite, however, is now taking place in London. Oxydizing disinfectants are by far the best known and most used, as they appeal directly to popular prejudice by destroying foul odors; whilst antiseptics have little or no action on these gases. This fallacious mode of estimating relative value is an injustice to antiseptics. In practical work, oxydizing disinfectants are always very inadequate, except for a short time after application. At other times the oxydizing agent has more noxious material than it can conquer; and, being governed in its combinations by definite laws of chemical affinity, the sulphuretted and carburetted hydrogen, the nitrogen and phosphorus basis, and other vapors, all have to be burnt up before the oxydizing agent can touch the germs of infection, whilst the renewal of the gases of putrefaction will constantly shield the infectious matter from destruction. Oxydizing disinfectants destroy infectant substances; antiseptics act by destroying its activity. Of all antiseptics, tar and acids are most powerful; and, of these, carbolic acid. By the latter, embryotic life is rendered well nigh impossible, and all minute forms of animal life perish inevitably. If the infectious matter of cholera possesses, as is now almost universally admitted, organic vitality, it will be destroyed beyond revival when brought into contact with this vapor. The addition of permanganate of potash to water will destroy the cholera virus. The oxydizing powers of this agent, although very energetic on dead organic matter, are successfully resisted by living organisms. The scientific prosecution of accurate experiments and observations in reference to the cholera, similar to those in respect of the cattle plague, are highly important, as the third report of the commissioners on the latter subject has given us more insight into that pestilence than we possess of any human zymotic disease, and there is no reason why a similar plan should not be carried out in this instance. — W. CROOKES, *in Reader*.

The Hastings Prize Essay on this subject, by Dr. Thomas Herbert Baker, is published in the number of the "British Medical Journal" for January 6, 1866. The following is a summary of the author's conclusions: —

1. For the sick-room, free ventilation, when it can be secured, together with an even temperature, is all that can be required.
2. For rapid deodorization and disinfection, chlorine is the most effective agent known.
3. For steady and continuous effect, ozone is the best agent known.
4. In the absence of ozone, iodine exposed, in the solid form, to the air is the best.
5. For the deodorization and disinfection of fluid and semi-fluid substances undergoing decomposition, iodine is best.
6. For the deodorization and disinfection of solid bodies that

cannot be destroyed, a mixture of powdered chloride of zinc, or powdered sulphate of zinc with sawdust, is best. A mixture of carbolic acid and sawdust ranks next in order; and, following on that, wood-ashes.

7. For the deodorization and disinfection of infected articles of clothing, etc., exposure to heat at 212° Fahr. is the only true method.

8. For the deodorization and disinfection of substances that may be destroyed, heat to destruction is the only true method.

COMPOSITION OF ANCIENT MORTARS.

The composition of ancient mortars has been examined by Dr. Wallace, and the results given in the "Chemical News." The first specimen was from the great pyramid, and presented the appearance of a mixture of plaster, of a slight pinkish color, with gypsum. It did not appear to contain any sand, the place of which was taken by coarsely-ground gypsum. Large quantities of this material and of alabaster are stated by Prof. Smyth to be found in the vicinity. Analysis showed this mortar to contain 82 per cent. of hydrated sulphate of lime, and 9½ per cent. of carbonate of lime, besides smaller quantities of other bodies. A very ancient mortar, supposed to be the most ancient in existence, was obtained from the ruins of a temple near Larnaca, in Cyprus. The temple is now wholly below the ground; still the mortar was exceedingly hard and firm, and appeared to have been made of a mixture of burnt lime, sharp sand, and gravel. This mortar contained chiefly 26.4 per cent. of lime, 20.2 of carbonic acid, 16.2 of silica, and nearly 29 per cent. of small stones, the lime being almost completely carbonated. Ancient Greek mortars showed somewhat the same composition. Ancient Roman mortars differed, however, being evidently prepared by mixing with burnt lime, not sand, but puzzeolana, or what is commonly, although improperly, called volcanic ash. From all his analyses, Dr. Wallace deduces the following conclusions: That in the course of time the lime in plasters and mortars becomes completely carbonated; that where the mortar is freely exposed to the weather, a certain proportion of alkaline or earthy silicate is formed, which probably confers hardness, as those mortars are the hardest which have been long below ground. It is known that those walls are strongest which are built during the rainy season, as then a small proportion of silicate of lime is formed, which not only makes the mortar itself harder, but causes it to unite more firmly with the stone. The mortar which is probably the most ancient is by far the hardest, appearing like concrete. Its excellence seems to indicate that a large-grained sand is best for building purposes; and that even small gravel may, in certain cases, be used with advantage.

COMPOSITION OF CAST-IRON.

Not only as a curiosity, but as a matter of profound interest to chemical and technical science, Prof. Remigius Fresenius of Wies-

baden has lately published a minute analysis of a black variety of cast-iron, which, besides a small amount of slag which was in mechanical combination, showed the following composition in 100 parts: —

	Per cent.
Metallic Iron	93.279
Metallic Aluminium	0.028
Metallic Manganese	0.388
Metallic Chromium	0.027
Metallic Vanadium	0.012
Copper	0.009
Arsenium	0.015
Antimony	0.011
Cobalt and Nickel	0.035
Zinc	trace.
Calcium	0.072
Magnesium	0.010
Titanium	0.024
Phosphorus	0.459
Sulphur	0.036
Silicium	3.265
Carbon (chem. comb.)	0.086
Graphite	2.171

MANUFACTURE OF WHITE-LEAD.

A recent number of the "Bulletin de la Société d'Encouragement" contains the text of a report by M. Barreswil on M. Ozouf's process for the manufacture of white-lead. It resembles in the main that proposed by Thenard many years since, in which carbonic acid gas is passed through a solution of subacetate of lead. The novelty consists in the manner of producing the carbonic acid, which is as follows: The gases proceeding from coke burnt in a specially-constructed furnace are, after having been washed, led through a series of vessels containing a solution of carbonate of soda, which thus becomes converted into bicarbonate. This solution is pumped into a cylinder, where it is raised to a boiling temperature. The effect of this operation is to drive off half the carbonic acid, which is then passed into a vessel containing a solution of basic acetate of lead, as in the ordinary method. M. Ozouf states that by proportioning the quantity of carbonic acid gas to the composition of the subacetate operated upon, he is able to produce at will white-lead of any definite composition, — a point of some practical importance. A specimen furnished by him showed on analysis a composition represented by the formula $3\ (PbO,\ Co_2) + PbO,\ HO$. Several ingenious contrivances for preserving the health of the workmen engaged in M. Ozouf's manufactory at St. Denis are described in the report.

NEW PROCESS OF MAKING SODA.

Mr. A. G. Hunter of Rockcliffe Hall, near Flint, has achieved a discovery, which seems likely to lead to a most valuable modification in the process of making soda. It has long been known

that caustic baryta will separate the sulphuric acid from a solution of sulphate of sodium, forming therewith an insoluble precipitate of sulphate of barium, and leaving caustic soda in solution. The decomposition of sulphate of sodium by caustic baryta is thus a far simpler and readier process than its decomposition by Leblanc's method; but caustic baryta has hitherto been, and is still, far too costly to permit of its use for the decomposition of sulphate of sodium on the great scale. Many attempts have been made to obtain it at a cheap rate from sulphate of barium, or "heavy spar," which is a sufficiently abundant natural product, but they have all been utter failures; and hence inventors have sought sedulously for some other and cheaper reagent, capableof acting, as regards sulphate of sodium, in the same way. Mr. Hunter has found a very cheap one, indeed. He has discovered that lime, by far the cheapest of all alkaline bodies, will separate the sulphuric acid from sulphate of sodium in solution, provided that the solution, after the lime has been added to it, be subjected to a pressure considerably exceeding that of the atmosphere. He states that "either hydraulic, steam, or mechanical pressure," will answer equally well. Unless the application of the necessary pressure, on the large scale, should prove to be attended with greater difficulties than there seems any reason to anticipate, his discovery will revolutionize the soda manufacture; and, by and by, all the carbonate of sodium produced will be obtained by the direct combination of caustic soda with carbonic acid, the caustic soda being obtained by a process embracing only two operations: (1.) the decomposition of chloride of sodium, or common salt, by sulphuric acid, as in Leblanc's process; and (2.) the decomposition of the resulting sulphate of sodium by lime.—*Mechanics' Magazine.*

PHENIC OR CARBOLIC ACID.

Phenic acid, or phenylic alcohol, is usually accompanied by its congeners, xylic and cresylic alcohols, which adhere to it with great tenacity, and give it the property of becoming brown in contact with the air. For its purification, M. Muller has recourse to a partial neutralization, and afterwards to the fractional distillation of the product.

The crude tar cedes to soda or lime water a mixture of the matters before mentioned, as well as naphthaline, which is soluble in concentrated solutions of the alkaline phenates. Water is added to this until it ceases to cause a precipitate, when the liquid is exposed in wide vessels, to facilitate the formation of the brown bodies and their deposit. After filtering, the approximative quantity of organic matter held in solution is determined, formed principally of phenic acid and its congeners, which are easily displaced by acids.

The phenic acid is always the last to separate, so that it is easy to disembarrass it of its associated matter and brown oxidized products by adding carefully the proportion of acid determined by calculation, so as to precipitate at first only these matters; and, by means of several trials, it is easy to arrive at the proper point

to stop, so as to retain the phenate nearly pure. The acid is now separated and rectified, and soon crystallizes. As a little water prevents its crystallization, Mr. Muller removes it by passing a current of dry air over the phenic acid nearly boiling.

The crystallization is facilitated by cooling, or by the introduction into it of a small quantity of the crystallized acid.

He insists on the necessity of exposing the alkaline solution of the acid for a long time, to favor the resinification and deposition of the brown matters; phenic acid is always impure when it is colored.

It should be quite pure when employed to make picric acid, because the impurities waste the nitric acid.

Phenic acid often contains a fetid substance, which appears to be a sulphuretted compound of phenyl or cresyle. It is removed by rectification from oxide of lead.—*From Zeitsch. fur Chem., in Journ. de Pharm., Nov.*, 1865.

It was first christened carbolic acid by Runge, a German chemist, who discovered it in 1834. But it is not properly an acid; it is not sour, does not redden litmus paper, nor does it combine with alkalies any sooner than with acids; hence the names phenol, etc.

Phenic acid, when pure, occurs in beautiful transparent needle-form crystals. If the crystals be exposed to the air, in a few minutes they absorb a very small quantity of moisture, and are transformed into an oily liquid, which is slightly heavier than water. Although the solid acid is so eager for water, it is satisfied with a very little, and is but slightly soluble in water. It has a burning taste, and a powerful and persistent odor, which people call smoky. It dissolves freely in alcohol, ether, and oils, and is itself a powerful solvent of gum, resins, sulphur, and phosphorus. We cannot more briefly indicate its more useful properties than to say it is often called creosote, and that it is as like the genuine creosote as two peas. It is a poison to all animals and plants, and is especially destructive to insects and their eggs. All vermin hate the smell of it, and get away from it as fast as they can. But, although it is certain death to the animal, it is kind to the dead body, for it may preserve that forever; any kind of flesh which has been impregnated with phenic acid refuses to decay and return to dust. When decay has commenced, by putrefaction or fermentation, phenic acid will stop it instanter, and prevent its recurrence.

The chief source of phenic acid is gas tar, while the genuine creosote is found in wood tar. Both are separated in substantially the same way. Phenic acid is probably as powerful an antiseptic as creosote, and for many purposes is a cheap substitute.

When nitric acid and phenic acid are brought together, picric acid, a splendid dye for yellow and green on silk and wool, is the result. Phenic acid, in the very crude form of gas tar and dead oil, has been used for preserving timber, and by the farmers for killing vermin. In the pure state it is generally known to physicians, and is used by many of them.

Phenic acid is now much talked about as a disinfectant, and especially in connection with the rinderpest. But its virtues as a disinfectant are doubtful. It promptly prevents the decomposition of matter which generates foul odors, but it acts slowly and poorly on the odors already existing. If it destroys an odor, it leaves itself in the place of it, and, to most people, will smell quite as bad. The first odor of phenic acid is tolerable, but when continued, it becomes exceedingly unbearable. — *Scientific American.*

HOW TO MAKE NITROGLYCERINE SAFE.

Prof. C. A. Seeley makes the following communication to the "Scientific American": —

In an article on this subject in the "Scientific American" of May 5, I made the assertion that the dangers from nitroglycerine are preventable, and that sure means were known by which its transportation and storage could be made safe. I shall now describe the most perfect of the plans proposed, and I ask that those who are interested in the subject will carefully weigh them.

1. Mr. Nobel proposes to dilute the nitroglycerine with wood naphtha. These two liquids mingle in any proportion, and the explosibility of the mixture may be reduced to any desired extent. Probably a mixture containing about twenty-five per cent. of naphtha could not be made to explode by percussion, or gradual heating. When the nitroglycerine is required for use, water is added to the mixture, and takes from it the naphtha, while the pure nitroglycerine sinks to the bottom. This plan is, however, liable to serious objections. (1.) The expense of the naphtha and loss of nitroglycerine in washing with water. (2.) The volatility of the naphtha: whenever the mixture is exposed to air some of the naphtha escapes, and the nitroglycerine might be left unprotected. (3.) It is probable that there would be a chemical action between the substances. (4.) The naphtha and the vapor from it are very combustible. The vapor mixed with air would be an explosive mixture.

2. It has been proposed by several persons, quite independently of each other, to keep the nitroglycerine mixed with sand, or other inert substance, which would serve as a conductor of heat, in the same way as the glass powder in Gale's gunpowder mixture. This plan would greatly increase the weight and bulk of packages, and great loss would be sustained by reason of the adhesion of the nitroglycerine to the sand.

3. Dr. Henry Wurtz proposes to make a thorough mechanical mixture or emulsion of the nitroglycerine with a saline solution of the same specific gravity. A solution of nitrate of zinc, lime, or magnesia, will probably be found to be suitable. When the nitroglycerine is needed for use, water is added to the mixture, when the oil subsides and may be drawn off. Further experience seems to be needed to determine how long the mixture may be maintained without spontaneous separation.

4. I have proposed to prepare the nitroglycerine more carefully, in order that it shall be perfectly freed from acid; and, to prevent

any future accumulation of acid, I propose to keep suspended in the oil a small quantity of a substance in powder which shall neutralize any acid which may be generated, and which of itself shall have no action on the oil. This method is offered as an efficient prevention of spontaneous decomposition. The amount of neutralizing powder required is very little, — sixty grains to the pound of oil might be sufficient. The quantity is so small that it would not interfere with the use of the oil, and need never be removed from it.

In actual practice, one or more of these plans may be combined. The fourth is compatible with all the others, and should be used with all the others. Nitroglycerine should not be kept in storage unless it is free from the danger of its most formidable property, — the liability to spontaneous change.

In conclusion, I can say that I have as yet had no reason to modify the opinions which I expressed in my communication of May 5; and that I still hold that the manufacture, transportation, and use of nitroglycerine may be carried on with safety.

COLORS FROM COAL TAR.

Aniline, or coal-tar colors have now been extended in number, so that all the colors of the rainbow, and all the shades, can be obtained from coal tar. Aniline was discovered by Unverdorben in 1826, who procured it by the destructive distillation of indigo. It is now obtained in small quantities directly from the destructive distillation of coal, as in gas-works, but is generally manufactured from the lighter coal-tar naphtha. When the naphtha is rectified, the portion which distils over at a temperature of 180° Fahr. is benzole, and this substance was discovered by Faraday in 1825. By the action of strong nitric acid, the benzole is converted into nitri-benzole; and this latter, when agitated with water, acetic acid, and iron filings, becomes aniline. By the action of oxidizing agents, such as chloride of lime, bichromate of potash, chloride of mercury, etc., the aniline, which is colorless by itself, can be transformed into all shades of violet, mauve, magenta, etc. By the researches of Hofmann, the number and beauty of the aniline colors have been increased. While numberless shades of reds and purples can be obtained, there is a splendid green, called verdine, discovered by Eusebe, and which remains a true, pure green even by candle or gaslight; a blue which is as clear as opal, a good yellow, and a fair black. In short, dyes of all hues can be obtained from aniline, which, in its turn, is procured from the coal tar. The intensity of these aniline colors may be indicated by the fact that one grain of magenta in a million of water gives a good red; one grain in ten millions of water exhibits a rose pink; one grain in twenty millions communicates a blush to the water; and one grain in fifty millions tinges the water with a reddish glow. — *Mining Journal.*

PRECIPITATION OF METALS BY MEANS OF MAGNESIUM.

M. Roussin has published a paper on the action of magnesium on metallic solutions, and on its application to toxicological researches, which shows that magnesium is particularly well adapted for the precipitation of other metals from solutions of their salts. It is a general principle, that one metal will precipitate from a saline solution any other which is less readily oxidable than itself; but some metals, by no means among the most oxidable known, had, nevertheless, when M. Roussin began his researches on this subject, resisted all attempts to precipitate them by the contact of another metal with their saline solutions. With two exceptions, however, all the metals alluded to are precipitated in the metallic state by magnesium, the two exceptions being chromium and manganese, which appear to be precipitated as oxides. Among the metals which M. Roussin has precipitated in the metallic state, by means of magnesium, from slightly acidulated solutions of their salts, are gold, silver, platinum, bismuth, tin, mercury, copper, lead, cadmium, thallium, iron, zinc, cobalt, and nickel. The precipitated metals, when washed from the saline liquid, and then dried and compressed, possess a very remarkable degree of brilliancy. Iron, cobalt, and nickel, so precipitated, are highly magnetic; zinc takes the form of a large spongy mass, which the least compression renders brilliant. Magnesium does not precipitate aluminium at all, and chromium and manganese, as already mentioned, it precipitates as oxides. It does not precipitate arsenic or antimony, though it decomposes their salts, the arsenic or antimony flying off in combination with hydrogen. M. Roussin shows that great advantages result from the substitution of magnesium for the metals ordinarily employed in toxicological researches for the detection of these and other metallic poisons; but into that part of his subject it would be beyond our province to follow him. His only further statement respecting magnesium, calling for mention here, is one relating to its use as a voltaic element. "The foregoing qualities," he says, "encouraged the hope that a substitution of magnesium for zinc in ordinary piles would offer a great electro-motive force; and experiment confirmed this theoretical inference. A small plate of magnesium, 0.1 grain in weight, placed beside a plate of copper in a small tube of glass of six centimetres cube, filled with acidulated copper, produced in less than ten minutes an electro-magnetic appearance, and illuminated a Geisler's tube ten centimetres long. If magnesium should ever become cheap, this would decidedly be the best way of producing electricity."

In a note to his paper, M. Roussin states that he has observed that a sodium amalgam, shaken up with an acidulous solution of a salt of chromium or of a salt of manganese, changes to an amalgam of chromium or of manganese, as the case may be; and that an amalgam of either of these metals, obtained in the manner indicated, when distilled in a current of hydrogen, after having been first carefully washed in acidulated water, leaves the pure metal in the form of a pulverulent sponge. "The amalgam

of manganese," he adds, "is opalescent and crystalline; that of chromium more fluid, and less variable at ordinary temperatures. When the latter is heated in a small porcelain capsule in the air, as the mercury flies off in vapor it carries off mechanically with it particles of chromium, which take fire, producing a singular scintillation, which is best observed in a darkened room. At length the chromium remaining in the capsule suddenly becomes incandescent, and burns to oxide."—*Mechanics' Magazine.*

BURNING OF A FRICTION MATCH.

Among the varied operations of the arts there is perhaps no other involving so many chemical and physical changes, and so many philosophical principles, as the burning of a friction match.

First in importance is the intense affinity of phosphorus for oxygen, as it is this property which makes a friction match possible. This affinity is so strong that when phosphorus is exposed to contact with the oxygen of the atmosphere at ordinary temperatures, the two substances combine slowly, generating light which is visible as a faint glow in the dark; and if the temperature is raised to about 120°, the combination goes on with that rapidity which we call combustion. It is easy to produce this degree of temperature of friction,—hence the possibility of the friction match.

It is necessary, indeed, to modify the inflammability of phosphorus for its use in a friction match, and this is done by mixing it with a little gum. The gum also protects it from slow combustion in the atmosphere.

The flame of phosphorus, though intensely hot, will not set fire to pine wood; it is, therefore, necessary to interpose some substance more readily inflammable than wood: the substance usually employed is sulphur. Pine wood ignites at a temperature of about 600°, and sulphur at 450° to 500°. The phosphorus, in burning, kindles the sulphur, and the sulphur flame sets fire to the wood.

The refusal of the phosphorus flame to kindle wood is fruitful of suggestions. The quantity of heat generated by the burning of any substance is in proportion to the quantity of oxygen with which the substance combines. One atom of phosphorus, in burning, combines with five atoms of oxygen, producing phosphoric acid, $P\,O_5$. The atom of phosphorus weighs 32, and the atom of oxygen 8, so the proportion by weight is 32 pounds of phosphorus to 40 of oxygen. Sulphur, in burning, combines with oxygen in the proportion of one atom of sulphur to two of oxygen, $S\,O_2$, and, as the atomic weight of sulphur is 16, the proportion by weight is 32 of sulphur to 32 of oxygen; consequently phosphorus should generate more heat in burning than sulphur.

Again, this law is modified by either the oxygen or the combustible undergoing a change of form in combining. If a substance is changed from the gaseous to the solid state, heat is evolved; if from the solid to the gaseous, heat is absorbed. Now, phosphoric acid is a solid, while sulphurous acid is a gas. Phos-

phorus, in burning, changes the oxygen, with which it combines, from the gaseous to the solid form, thus increasing the quantity of heat generated; while sulphur, in burning, is changed from the solid to the gaseous state, thus absorbing heat, and diminishing the quantity produced by the combustion.

These theoretical views have been confirmed by careful experiment. The results obtained by Andrews from his elaborate investigations were, that 1 pound of phosphorus in burning to phosphoric acid generates sufficient heat to raise the temperature of 5,747 pounds of water 1° C.; while 1 pound of sulphur, in burning, raises the temperature of only 2,220 pounds of water 1°.

But it is not the quantity of heat that is to be considered in this case, but the intensity; which is in proportion to the quantity contained in a cubic inch or other given volume. This, however, only increases the difficulty, for the phophorus flame being condensed to a solid, while that of sulphur is diffused as a gas, the intensity of heat ought to be still more in favor of the phosphorus than the quantity.

The usual explanation given for the failure of wood to ignite in a phosphorus flame is, that the surface of the wood is instantly covered by a film of phosphoric acid, which protects it from combustion. As we have no better explanation to offer, we raise no objections to this.

The products of combustion, then, in the burning of a match, are, first, phosphoric acid from the burning of the phosphorus; then sulphurous acid, from the burning of the sulphur; and, finally, carbonic acid and water from the burning of the wood.

This is far from being an exhaustive examination of the subject. The hydrogen and carbon of the wood do not combine directly with the oxygen of the air, but the wood first undergoes destructive distillation, with the production of several hydrocarbon gases, which rise in the air and produce the flame by their combustion; and, after the wood is burned, the ash that is left behind is made up of some sixteen elements, combined with oxygen in various proportions. The activity of the burning, also, is increased by adding to the paste some substance containing oxygen which is held by feeble affinity, and which is, therefore, readily given up to the sulphur, phosphorus, and wood. Among the substances employed for this office are saltpetre and the peroxides of lead and manganese. In a complete examination of the reactions of the combustion, the decompositions of these oxidizing agents, with the resulting compounds or elements, would demand consideration. All that might be said in relation to the burning of a friction match would fill a large volume. — *Scientific American.*

OXIDATION OF VEGETABLE OILS.

In a memoir upon this subject, read to the Academy of Sciences of Paris, M. Cloez announces the following results of his experiments and observations: —

1. That all the fat oils absorb oxygen from the air, and increase in weight by quantities which differ, for different kinds of oil

placed under the same circumstances, and for the same oil under different circumstances.

2. That the height of the temperature exercises a very marked influence on the rapidity of the oxidation.

3. That the intensity of the light also manifestly influences the phenomena.

4. That light transmitted by colored glasses checks more or less the resinification of the oils by the air. Starting from colorless glass as the term of comparison, the decrease of oxidation is in the following order: Colorless, blue, violet, red, green, yellow.

5. That, in darkness, the oxidation is considerably retarded; it starts later and progresses more slowly than in light.

6. That the presence of certain materials, and the contact with certain substances, accelerate or retard this effect.

7. That, in the resinification of oils, there is both a loss of carbon and hydrogen of the oil, and an absorption of oxygen.

8. That the different oils, in oxidizing, furnish in general the same products, — volatile acid compounds, liquid and solid fat acids not altered, and an insoluble solid material, which appears to be a definite proximate principle. Oils oxidized in the air no longer contain glycerine.

9. The drying and non-drying oils are not chemically distinguishable. All contain the same glyceric proximate principles, but in different proportions.

PEROXIDE OF HYDROGEN.

Professor Schönbein has discovered a new and very ready method of procuring the peroxide of hydrogen. It consists simply in agitating, in a large flask, to which air has access, amalgamated zinc, in powder, with distilled water. Oxygen is then absorbed by both the zinc and the water, with formation of oxide of zinc and peroxide of hydrogen. The peroxide of hydrogen obtained by this method, unlike that obtained by the ordinary process, is quite free from acid, and so may be kept for a long time without decomposition. It does not contain, moreover, a trace of either zinc or mercury, but is absolutely pure. This new process has therefore great advantages over the old process of preparing peroxide of hydrogen, both as being far simpler and more expeditious, and as yielding a much purer product; but it is almost as far as the old process from yielding peroxide of hydrogen cheaply enough for use in the arts.

OZONE.

The Paris correspondent of the "London Chemical News" writes as follows: —

"The rumor which you helped to spread abroad that Schönbein has succeeded in isolating ozone and antozone, attracted, it seems, the notice of the Scientific Association of France, and that learned body invited Schönbein to come to Paris and exhibit his

experiments to the wondering gaze of Parisian savans. Schönbein's reply gives us the exact state of his knowledge or belief on the subject, and is worth communicating to English chemists. He says that he has been engaged almost exclusively, and without interruption, in the study of oxygen for thirty years, and during this time he has discovered a number of facts which allow of his drawing the following conclusions: 1. That oxygen may exist in three different allotropic states. 2. Two of these states are active, and opposed one to the other: he designates one of them ozone, and the other antozone. 3. Equal quantities of ozone and antozone neutralize each other to form ordinary neutral or inactive oxygen. 4. Ordinary neutral oxygen may be split up or transformed, half into ozone and half into antozone. The experimental demonstration of the truth of these conclusions, however, he admits, is not so simple, — as, for example, the composition and decomposition of water; and he adds that the experiments necessary for their logical deduction would occupy more time than could be devoted to a single lecture. 'Some scientific journals,' says Schönbein, 'have been badly informed, when they asserted that I had succeeded in isolating ozone and antozone in a state of purity. The assertion is without foundation. It is true, that, for a long time, I have made a great number of attempts to arrive at this desirable end; but always without complete success. Ozone and antozone are always mixed with neutral oxygen, from causes closely associated with the generation of the two active modifications.' The Professor concludes his letter by offering to come to Paris, should it still be desired, and if his health permit, and give a short course illustrative of the whole subject. It is to be hoped he will be invited, and, while here, perhaps he might be induced to go on to London, which I do not think he has visited since the year he announced his discovery of ozone."

Dr. Daubeny, before the British Association, 1866, made a communication on ozone. He considered, first, the dependence of the amount of ozone present in the atmosphere on the direction of the wind, and proved, by tables registering the quantity during a period of eight months, that in Devonshire it abounded most during those winds which blew from the sea. He then proceeded to show that the ozone present in the air was derived partly, at least, from plants, the green parts of which generate ozone when they emit oxygen. By observations made on fifty-seven species of plants, representing forty-seven natural families, it was concluded that a certain amount of coloration was produced upon Schönbein's paper by leaves during the continuance of solar light, beyond what could have been brought about by light alone, but that this coloration did not go on progressively at any definite rate, and even in certain cases diminished after a longer exposure. Precautions were taken to exclude from the air of the jar any ozone that might come from without. Then the effects produced upon the paper placed in tubes exposed to different light, and in entire darkness, were noted. It was shown that ozone was generated by the leaves only, and not by the flowers of plants; and, on the whole, it seemed to be fairly presumable that plants are the appointed agents, not only for restoring the oxygen which animals consume, but also

generating ozone for removing those noxious effluvia which arise from the processes of animal life and putrefaction.

Mr. Glaisher then proceeded to relate the results of experiments in ozone, made by him in London at the time of the cholera, 1854, which were, that where the test-papers were discolored, there death was extremely rare, and *vice versa*.

Does ozone exist in the atmosphere? That is the question asked by Admiral Berigny, of the French Academy of Sciences, who, after having patiently made what he conceived to be ozonometric observations for the last ten years, and assisted M. Le Verrier in selecting stations for similar observations all over Paris, and in every department of France, has been brought at last to doubt whether the observations are good for anything; so he beseeches the Academy to appoint a commission to settle definitively, — 1. Whether ozone exists in the atmosphere? 2. Whether Schönbein's or anybody else's papers prove the presence of electrized oxygen? and, lastly, whether an easy and reliable method of detecting it could not be devised? The Academy appointed a commission composed of Chevreul, Dumas, Pelouze, Pouillet, Boussingault, Le Verrier, Valliant, Frémy, and E. Becquerel, whose report will no doubt scatter popular notions on atmospheric ozone to the winds.

To say the truth, the evidence in favor of the presence of ozone in the atmosphere is, as M. Frémy showed to the Academy, of the most doubtful character. M. Frémy said that he knew of only one certain test for ozone in the air, and that was the oxidation of silver, by passing a current of moist air over the metal; and this test he had applied many times without any indication of ozone. We are very far from being acquainted, he said, with all the bodies held in suspension in the air, and, consequently, ignorant of the action they may exert on iodide of potassium. May not, he asked, this salt become alkaline, or set free iodine under other influences besides that of ozone? He did not deny the fact of its presence, but he asked a positive proof of it. Such a proof is required; for, seeing that ozone is instantly destroyed by organic matters, and absorbed by nitrogen, it is difficult to understand how such a body can continue to exist in the air, which contains precisely the elements which would at once change the ozone. As regarded the test-papers he asked, what use there could be in a reagent which was affected not only by ozone, but by the oxygen compounds of nitrogen, by oxygenated water, by ammonia, by formic acid, by essential oils, by the acid products of combustion, by dusts, — in a word, by all sorts of things which are held in suspension in the air. — *Druggists' Circular*, 1866.

Our actual knowledge of the volumetric relations of oxygen, says M. Soret in a note presented to the French Academy, is limited to the following facts: 1. That ordinary oxygen diminishes in volume when a part is converted into ozone. 2. That when ozonized oxygen is treated with iodide of potassium or other oxidizable matter, the ozone disappears without any alteration in the volume of the gas. 3. That under the influence of heat, ozonized oxygen undergoes an expansion equal to the volume that the part absorbable by iodide of potassium would occupy. Regarding a molecule of ordinary oxygen as composed of two atoms of OO,

the author considers the molecule of ozone as consisting of three atoms of OO,O occupying the same space as the two. Treated with iodide of potassium, ozone loses one atom of O without any change of volume; submitted to heat, the volume is increased by one-half. Thus the theoretical density of ozone should be one and a-half times that of ordinary oxygen, or 1.658; and the author considers he has experimentally demonstrated that such is the fact.

Dr. B. W. Richardson, in a paper read before the British Association for the Advancement of Science, at its late meeting, observed that the following are the reliable facts known up to this time respecting ozone: 1. Ozone, in a natural state, is always present in the air in minute proportions, viz., one part in ten thousand. 2. It is destroyed in large towns, and, with special rapidity, in crowded and filthy localities. 3. Ozone gives to oxygen properties which enable it to support life. In this respect it acts like heat; its effects are destroyed by great heat. 4. Ozone, diffused through air in minute quantities, produces, on inhalation, distinct symptoms of acute catarrh. 5. When animals are subjected to ozone in large quantities, the symptoms produced, at a temperature of 75°, are those of inflammation of the throat and mucous membranes generally, and at last congestive bronchitis, which, in carnivorous animals, are often rapidly fatal. 6. When animals are subjected for a long period to ozone in small proportions, the agent acts differently, according to the animal. The carnivora die, after some hours, from disorganization of the blood separation; but the herbivora will live for weeks, and will suffer from no acute disease. 7. The question whether the presence of ozone in the air can produce actual disease, must be answered cautiously. Science has yet no actual demonstrative evidence on the point. But the facts approach to demonstration that catarrh is induced by this agent. All else is as yet speculative. 8. During periods of intense heat of weather, the ozone loses its active power. 9. On dead organic matter undergoing putrefaction, ozone acts rapidly; it entirely deodorizes by breaking up the ammoniacal products of decomposition. At the same time it hastens the organic destruction. 10. There is an opposite condition of air in which the oxygen is rendered negative in its action, as compared with the air when it is charged with ozone. Air can thus be rendered negative by merely subjecting it, over and over again, to animals for respiration. The purification of such air from carbonic acid and other tangible impurities does not render it capable of supporting healthy life; but ozone restores the power. In a negative condition of air, the purification of the organic matter is greatly modified, and the offensive products are increased. Wounds become unhealthy and heal slowly in such negative air. 11. There is no demonstrative evidence, as yet, that any diseases are actually caused by this negative condition of air; but the inference is fair, that diseases which show a putrefactive tendency are influenced injuriously by a negative condition of the oxygen of the air. It is also probable that, during this state, decomposing organic poisonous matters become more injurious. 12. As ozone is used up in crowded localities, and as it is essential that ozone should be constantly supplied in

order to sustain the removal of decomposing substances and their products, no mere attention to ventilation and other mechanical measures of a sanitary kind can be fully effective, unless the air introduced be made active by ozone. Fever hospitals and other large buildings in towns should be artificially fed with ozonized air.

ANTOZONE.

The vapors accompanying the slow combustion of phosphorus have, by certain chemists, been regarded as phosphorous acid. M. Schönbein considers them to be nitrate of ammonia; while M. Meissner, again, sees in them antozone. With a view of clearing up this point, M. Osann has passed these vapors into solutions of ammoniacal nitrate of silver and alkaline solutions of oxide of lead. In the first place, a black precipitate was obtained; this precipitate contained, on an average, 97.28 of silver to 2.72 of oxygen, which composition corresponds to the formula Ag_3O. The author at first thought that the oxygen contained in this precipitate was ozone, which, having more powerful affinities than ordinary oxygen, had displaced the latter in the oxide of silver; but the oxidizing nature of ozone has caused him rather to attribute the formation of this body to a deoxidizing action such as produces antozone. He afterwards passed the same vapors, first into an alkaline solution of pyrogallic acid, to retain the ozone; then, partly into one of Woolf's bottles containing a little water; partly into an ammoniacal solution of nitrate of silver. In this case the same precipitate was obtained, though all the ozone must have been absorbed by the pyrogallic acid.

The water in Woolf's bottle, which had remained in contact with the vapors from the phosphorus, was shaken with blued tincture of guaiacum, which immediately lost its color. The same thing happened with nitrate of ammonia and oxygenated water, but much more slowly with the latter, though it was highly concentrated. Hence the author does not hesitate to say, that, in his experiment, the decoloration was due to nitrate of ammonia; and, consequently, he attributes the vapors produced during the slow combustion of phosphorus to the formation of this body. — *Journal für Praktische Chemie.*

Mr. Alfred R. Catton, after stating the reasons which have induced him to adopt the hypothesis of Prof. Odling on the nature of ozone ("Chemistry Manual" of 1861), mentions the experiments which establish the existence of antozone. He then considers its properties in detail, so far as they have been hitherto observed by Schönbein and Meissner, and shows that they all lead to the conclusion that antozone is peroxide of hydrogen, in which the hydrogen is replaced by oxygen, or representing peroxide of hydrogen by the formula

$\overset{+}{H_2}\,\overset{-}{O}\,\overset{+}{O}$ ($O = 16$), in accordance with the views of Sir Benjamin Brodie ("Phil. Trans.," 1850),

Antozone is $\overset{+}{O}\,\overset{-}{O}\,\overset{+}{O}$.

Prof. Odling represents ozone by the formula $\overset{-}{O}\,\overset{+}{O}\,\overset{-}{O}$.

The production of ozone and antozone by the passage of electric sparks, or the silent discharge through dry oxygen, is thus represented by the following equation: —

$$\underbrace{\overset{-}{O}\overset{+}{O} + \overset{-}{O}\overset{+}{O} + \overset{-}{O}\overset{+}{O}}_{\text{Free Oxygen.}} = \underbrace{\overset{-}{O}\overset{+}{O}\overset{-}{O}}_{\text{Ozone.}} + \underbrace{\overset{+}{O}\overset{-}{O}\overset{+}{O}}_{\text{Antozone.}}$$

SUMMARY OF CHEMICAL NOVELTIES.

Transformation of Nitrate of Soda into Nitrate of Potash. — M. Condurie has patented the following processes: He makes concentrated and equivalent solutions of nitrate of soda and chloride or sulphide of barium, and mixes the solutions. Nitrate of baryta, which is but sparingly soluble, is precipitated. It is well washed, and then boiled with sulphate of lead, whereby nitrate of lead and sulphate of baryta are produced. The nitrate of lead is now boiled with sulphate of potash, and so nitrate of potash is formed, and sulphate of lead reproduced.

Production of Oxalic Acid. — Three French chemists, MM. Laurent, Castheler, and Basset, have succeeded in obtaining oxalic acid from the waste of shoemakers' and saddlers' shops, and others, where leather is used; also from woollen rags, horn, hair, etc. For this purpose, these residues are treated with one part of sulphuric acid and four of water; and the mass thus obtained is subjected to the action of one part of nitric acid and three of water, at a temperature of 80° C. From the digestion of this, oxalic acid is easily extracted.

Process for the Condensation of Ammoniacal Gas. — Knab has found that chloride of calcium absorbs its own weight of ammoniacal gas, which is again evolved on the application of heat. The chloride will serve an indefinite time. M. Knab considers that his discovery will be found very useful. 1. Because chloride of calcium saturated with ammonia is dry powder, easy of transport. 2. Because chloride of calcium is of very little value. 3. While water will only hold in solution 20 per cent. of ammonia, the chloride will hold 50 per cent., so that the cost of sending ammonia about will be greatly diminished.

On the Action of Metalloids upon Glass, and on the Presence of Alkaline Sulphates in Glass. — M. Pelouze, finds that, 1. All commercial glass contains sulphates. 2. Glass made from materials not containing sulphates is not colored by carbon, boron, etc. 3. Sulphur and sulphurous minerals impart a yellow color to pure glass. 4. The color produced in glass by metalloids is entirely due to their reducing power.

Black Color of Tea. — A black color is often communicated to tea by moist brown sugar; this is produced by the presence of a minute quantity of iron in the sugar, which combines with the tannic acid of the tea, forming the very black tannate of iron. This iron is obtained during the manufacture in iron vessels, and is rather wholesome than otherwise.

Analysis of Hailstones. — The results of Professor Reichardt's analyses of hailstones are published in No. 6 of the "Chemisches

Centralblatt." The specimens examined weighed from 1.86 to 4·65 grains, the specific gravity, which was ascertained by floating them in alcohol of known density, varying between 0.9285 for the transparent and 0.9234 for the opaque hailstones. Tested for nitrous acid with Schönbein's iodide of starch papers, a negative result was obtained, in spite of the great sensitiveness of the papers. 1,000,000 parts of hail were found to contain 3.247 of ammonia and 0.526 parts of nitric acid. This agrees tolerably well with Boussingault's analyses, which gave in 1,000 parts of rain-water 2.16 parts of ammonia.

To Detect Sulphuric Acid in Vinegar.—If into pure vinegar starch is introduced, then the adding of a minute portion of iodine will change its color to a blue tint; but, if sulphuric acid is present, no such reaction will take place, for the resultant of starch in its presence is glucose, a substance not affected by iodine.

Rubidium and Cæsium.—Schrötter has devised a new process by which both the above metals, and lithium as well as thallium, may be readily extracted from the lepidolite of Moravia and the mica of Zinnwald. It consists in transforming and separating them in the form of alums, by their difference of solubility in water. By this method, the first trials, on a large scale, yielded, from a ton of mica, 62 lbs. of carbonate of lithia, and 13 lbs. of the mixed chlorides of rubidium and cœsium, together with an appreciable quantity of thallium.

Excellent and Cheap Ink.—Dissolve in about 4 gallons of hot water 3 ounces of solid extract of logwood; to this add ½ ounce of bichromate of potash, dissolved likewise in a little hot water. As soon as the liquids are mingled, they assume an intense purple-ish-blue color, and the ink thus prepared may be used at once; it acquires a black color on the paper while drying, and does not corrode steel pens, and does not fade. The cost of materials is about three cents per gallon.

New Green Pigment.—Vogel describes a new color, "Green Cinnabar," which is prepared in the following way: Prussian blue is dissolved in oxalic acid; chromate of potash is added to the solution, which is then precipitated with acetate of lead. The precipitate, well-washed, dried, and levigated, gives a beautiful green powder. By varying the proportions of the three solutions, various shades of green may be procured. Chloride of barium or nitrate of bismuth may be used in place of sugar of lead.

Solution of Silk.—A solution of silk may be made by boiling it with a concentrated solution of chloride of zinc over an excess of oxide of the same metal, until it no longer discolors the tincture of litmus. By dialysis, the silk may be obtained again in a colorless inodorous form.

Test for Cane Sugar.—H. Leplay observes that the sugar of grapes blackens bichloride of carbon, while cane sugar does not. —*Les Mondes, Dec.* 14, 1865.

Artificial Cold.—Mr. Clowes finds that when sulpho-cyanide of ammonium is dissolved in water, intense cold is produced in a short time, the atmospheric moisture being deposited like hoar

frost on the sides of the vessel. From trials with different proportions, he found that the mixture of equal parts by weight gave the most intense cold. By mixing 1368 grains of the salt with its weight of water at 17° C. a cold of — 12° C. was obtained; the temperature of the atmosphere at the time of the experiment was the same as that of the water employed.— *Quarterly Journal of Science, April,* 1866.

Chemical Poisoning.—M. Melsens states, in "Comptes Rendus," that chlorate of potash and iodide of potassium may be administered in considerable quantities in succession to dogs, without injuring them; while, if they are given simultaneously, the animals are poisoned, apparently by the formation of iodate of potash. He observes that the two salts do not react in this way under ordinary circumstances, but they do so in strong acid solutions, or when in fusion, and when mixed and decomposed by the electric pile.

Orange-colored Dye from Aniline.—Mr. Jacobsen makes red aniline in the usual way by the action of nitrate of mercury on aniline. The residue is then purified by boiling the resinous deposit, crystallizing the solution. The mother liquor of the crystals contains small quantities of dyes of different colors, and a large proportion of orange dye. The orange is isolated by means of common salt, which precipitates the other colors and leaves the orange in solution. The dye is afterward extracted with alcohol. The color is a golden orange, which readily dyes silk and wool, and Mr. Jacobsen speaks of using it as a sort of varnish for optical instruments and on tinfoil.— *Cosmos.*

Chrome Avanturine Glass.—Under this name, M. Pelouze describes a beautiful variety of ornamental glass, composed as follows: sand, 250 parts; carbonate of soda, 100 parts; carbonate of lime, 50 parts; bichromate of potassa, 40 parts. This glass melts with greater difficulty than that without the bichromate, is of a deep green color, and full of small spangles, crystals of oxide of chrome, which sparkle with a brilliancy inferior only to the diamond.

Tests for Carbolic Acid.—Carbolic acid is now largely used as a disinfectant, for which it is pre-eminently fitted, especially in cases of cattle disease. It appears that a spurious article, composed of oil of tar, utterly valueless as a disinfectant, is now being imposed on the public. Mr. W. Crookes directs attention to this fraud, as well as to the following means by which it may be detected. Commercial carbolic acid is soluble in from 25 to 70 parts of water, or in twice its bulk of a solution of caustic soda, while oil often is nearly insoluble. To apply these tests: 1. Put a teaspoonful of the carbolic acid in a bottle, pour on it half a pint of warm water, shake the bottle at intervals for half an hour, when the amount of oily residue will show the impurity. 2. Dissolve 1 part of caustic soda in 10 parts of warm water, and shake it up with 5 parts of the carbolic acid; as before, the residue will indicate the amount of impurity. These tests are not scientifically accurate, but sufficiently so for common use.— *Mech. Mag., April,* 1866.

Ancient Stained Glass.—It has been found that the colors of ancient stained glass may be completely restored by leaving it immersed for several days in a solution of carbonate of soda, which dissolves away the organic matter to which in part the dimness produced by age is due, and then immersing it for several hours in dilute muriatic acid to remove the mineral substances, which also impair the brilliancy of the colors.

Magnesium.—Magnesium light contains an extraordinary proportion of ultra-violet or chemical rays, this part of the spectrum between the extreme violet and the extreme red being six times as large as usual, and it is particularly efficient for producing fluorescent and photographic effects. Very remarkable fluorescence may be obtained by exposing to the light a paste made of powdered platino-cyanide of barium and gum arabic.

Nature of the Diamond.—Goeppert, in his published essay on the "Organic Nature of the Diamond," shows that it cannot be of igneous origin; for it turns black when highly heated. Moreover, it contains sometimes, beside other crystals, germs of fungi, and vegetable fibres of higher organizations.

American Sienna.—A valuable repository of this precious pigment exists in the town of Whately, Conn., which will soon be brought into extensive use.

Passive State of Metals.—The so-called passive state of metals has been proved by Dr. Heldt to result from the formation of an insoluble film, differing in different cases, but always protecting the metal from the attack of the acid or other solvent.

NEW AND RARE MINERALS.

Laurite; a New Mineral.—Wöhler has discovered among the fine-grained platinum ore from Borneo, a new mineral, a sulphide of ruthenium and osmium, to which he had given the name of Laurite. It occurs in small grains of a dark iron black color and high lustre. Most of the grains are true crystals, and Sartorius has recognized the mineral to have the form of the regular octohedron, in some instances showing cubic, tetrahexahedral, and other planes. It is brittle, yielding a dark gray powder on pulverization; hardness above that of quartz; specific gravity 6.99; decrepitates when heated; infusible before the blowpipe. Analysis gave ruthenium 65.18, osmium 3.03, sulphur 31.79 (approximate). Formula $Ru_2 S_3$ 91.8, $Os S_4$ 8.2. This is the first instance of the occurrence of a natural sulphide in the group of platinum metals.—*Ann. Chem. Pharm.*, 139, 116.

Pachnolite.—Knop has recently discovered in the decomposed and weathered cryolite a new mineral, to which he has given the name of Pachnolite, from its resemblance to hoar frost. He gives the chemical composition as Fl. 50.79, Al. 13.14, Na. 12.16, Ca. 17.25, H. 9.60 = 102.94. Dr. G. Hagemann, of the Alkali Works at Natrona, Penn., has examined this mineral, and fully confirms M. Knop's results. Cryolite is now largely imported to Natrona from Greenland, for the purpose of manufacturing soda-ash, alumina salts, and other products.—*American Journal of Science.*

Rare Minerals. — Cœsium, from *cæsius* "sky-colored," owing to two blue lines which it produces in the spectrum; rubidium, from *rubidus*, "dark red," owing to the existence in its spectrum of two red lines of remarkably low refrangibility; thallium, discovered by Mr. William Crookes, which derives its name from *thallos*, "a budding twig," symbolizing the green tint of budding vegetation; indium, discovered by Reich and Richter of Freiburg. All of these are due to the introduction into science of a mode of investigation known as the spectrum analysis.

Position of Thallium in Classification. — Mr. Crookes persists in arranging thallium near lead, while Mr. Lamy is equally decided in placing it among metals of the first section. In a review of all the facts and considerations in the "Journal of Chemistry and Pharmacy" (Nov., 1865), I have shown the possibility of resolving the question by placing thallium with the alkali metals, but also including with it lead and silver. This opinion confirms a theory brought forward twenty years since by Mr. Baudrimont, who even then ranked lead with barium. Now that we have an alum with a base of oxide of silver, isomorphous with the alum of thallium, that of potassium, etc., there is less objection to putting in the same group all these metals, although in other respects they are quite dissimilar. The facts mentioned tend to show that thallium should be considered as establishing a point of union between the alkali metals on one side, and lead and silver on the other. — *J. Nicklès, in Silliman's Journal, Jan.*, 1866.

Spectrum of Didymium. — Prof. Bunsen has announced a new fact relating to the spectrum of the rare metal didymium. He has found that when the spectrum of this metal is examined by polarized light, the position of its well-known black absorption lines varies with the direction in which the light passes through the crystal, — a proof that the position of absorption lines is influenced by the physical structure of the bodies through which the light passes.

Indium. — Reich and Richter have obtained enough of this new element, to determine its physical properties. It is a white metal, soft, ductile, not easily tarnished, melts at about the same point as lead, and gives a blue color to flame when combined with chlorine or sulphur. Its specific gravity is 7.277, and equivalent 37.07, that of hydrogen being one.

Kachler has shown that in the zincblende of Schönfeld, near Schlaggenwald, the new metal *indium* is associated with tin and other metals in sufficiently large quantity to be extracted therefrom to the extent of several grammes. The blende is calcined; it is dissolved in sulphuric acid, and the solution is treated with metallic zinc; the indium is then precipitated, mixed with other metals, which are afterward separated.

Alloclase. — We learn from "Cosmos" that a new mineral has been discovered at Oravicza, in the Banat, to which M. Tschermak has given the name Alloclase. The mineral is composed of sulphur, arsenic, bismuth, and cobalt, in the mode expressed by the formula $Co_6 As^5 S_9$, in which it is supposed that one-fourth of arsenic may be replaced by an equal quantity of bismuth. It

forms rhombohedric crystals of a copperish gray color, found in calcite, and accompanied with acicular arsenical pyrites. Breithaupt has confounded alloclase with glaucodote. — *Reader*.

NATIVE LEAD FROM LAKE SUPERIOR.

On the American continent — apart from its occurrence in the meteoric iron of Tarapaca, in Chili — native lead has hitherto been noticed only at one spot, viz., in a galena vein, traversing limestone (of unstated geological age), near Zomelahuacan, in the province of Vera Cruz, in central Mexico. The specimen from the locality now under consideration, was obtained at a spot near the celebrated Dog Lake of the Kaministiquia. The lead occurs in this specimen — the only one discovered — in the form of a small string in white, semi-opaque quartz. The quartz, which forms a narrow vein, does not appear to contain the slightest speck of galena, or any other substance, except a small quantity of specular iron ore; and the unaltered appearance of the latter is such as to preclude the supposition of the lead having been derived from galena, or other lead compound, by artificial heat. The lead, when cut, presents the ordinary color, softness, ductility, and other physical and chemical properties of the pure metal.

This discovery is interesting, not only from the extreme rarity of native lead, but from the fact that, in the few undoubted European localities in which the metal has been found, the latter is generally accompanied by gold. The quartz in which this specimen occurs, has, curiously enough, the somewhat waxy aspect and other characters of the gold-bearing quartz of California and other auriferous districts; and the geological position of the bounding rock, immediately above that of the Huronian strata, is in a measure identical with the horizon of the gold-bearing rocks from which the auriferous deposits of Eastern Canada have been derived. No gold has hitherto been met with, however, in the sands of the Kaministiquia and other streams of Thunder Bay. — *Canadian Journal, November*, 1865.

BORAX IN CALIFORINA.

Clear Lake is about sixty-five miles northwest of Suisun Bay, and about thirty-six miles from the Pacific Ocean. Borax Lake occupies a depression on the east side of the narrow arm of Clear Lake, from which it is separated by a low ridge of loose volcanic materials, consisting of scoriæ, obsidian, and pumice. Borax Lake is of variable dimensions, according to the season of the year and the comparative dryness of the season. In September, 1863, the water occupied an area about 4,000 feet long and 1,800 feet wide in the widest place, irregularly oval, its longer axis turned in the direction of east and west, magnetic; the water was about three feet deep; it has been known to extend over twice this area, and has also been at times entirely dry. The water from this lake, in September, 1863, contained 2,401.56 grains of solid matter to the gallon, of which about one-quarter was borate of soda, there being

281.48 grains of the anhydrous biborate, equal to 535.08 of crystallized borax to the gallon. The borax, being the least soluble substance contained in the water, has, in process of time, crystallized out to a considerable extent, and now exists in the bottom of the lake in the form of distinct crystals of all sizes, from microscopic dimensions up to two or three inches across. These crystals form a layer immediately under the water, intermixed with blue mud of varying thickness. It is believed by those who have examined the bottom of this lake that several million pounds of borax may be obtained from it by means of movable coffer-dams, at a moderate expense.

According to the San Francisco papers, during the year 1865 this lake supplied the local demand for borax to the amount of thirty to forty tons, and afforded two hundred tons for shipment to New York. The borax is collected from the mud at the bottom of the lake, during the dry season, the yield in 1865 averaging about two and one-half tons per day. The crude borax, thus obtained, is so pure that the mint and assayers of the city use it in preference to the refined article brought from abroad. — *American Journal of Science, March*, 1866.

CELESTIAL CHEMISTRY.

SPECTRUM ANALYSIS.

The Spectroscope and its Revelations.—Within the last few years a new form of chemical analysis has arisen, which ascertains substances by observation upon the color and properties which they impart to flames during combustion. It has been long known that the combustion of certain bodies gave certain colors to flames; strontia, for example, affording the beautiful crimson so well known in pyrotechny. But no sure method existed of using the facts of combustion for chemical investigations, until the invention of the spectroscope. Spectrum analysis enables us to detect the minutest trace of the constituents of substances burnt. It has already discovered several unsuspected new metals; has given us the power of analyzing bodies whose composition we had not the means of ascertaining, and has proved to us that many of the elements of the earth are present in the inaccessible sun, and even in those more remote stars whose distance the most refined researches of astronomy cannot determine.

The spectroscope is merely a prism to which light can be admitted through a slit one-thirty-second of an inch wide, with apparatus for examining microscopically the spectrum or decomposed ray beyond the prism. When this is done, the spectrum is found to be crossed by an infinite number of lines perpendicular to its length. These lines are called, from the name of the distinguished optician who discovered them, Fraunhofer's lines.

When the light coming from a white-hot mass of metal is examined by the spectroscope, its spectrum is found to be perfectly continuous and unbroken by any Fraunhofer lines. What is the cause of the lines in the solar light, and in what does that luminary differ from the incandescent mass?

In order to fathom this question, we must investigate for a few moments the case of artificial lights, such as ordinary flames, and those in which there are purposely introduced various elementary or compound bodies. The construction of the spectroscope must also be described.

The spectroscope is sometimes a very complicated instrument, but, for ordinary analysis, quite a simple form may be used. It consists of a prism, supported on a stand. Two telescopes, of low magnifying power are attached by suitable supports. One of these is furnished with an eye-piece like any common spy-glass, but the eye-piece of the other is removed, and in its place is put a vertical slit. Opposite this slit the flame to be examined is placed. The light coming through the slit from the flame falls

upon the object-glass of the first telescope, and its rays are rendered parallel; it then passes through the prism, is refracted and decomposed, and enters the second telescope, whence it falls upon the eye. Any flame may be put opposite the slit, and its peculiarities examined, or, by the aid of a reflector, the sunlight may be cast on part of the slit, so that we can see a solar spectrum alongside of the flame spectrum. Or, we may have the spectra of the two flames at once, and compare them. The third telescope carries a scale.

The use of a spectroscope merely involves placing the substance to be examined in a spirit or gas flame, and then looking through the telescope to examine the spectrum. The number, position, and color of the transverse lines are always the same from the same substance. A person soon becomes experienced enough to state in a moment what bodies are present.

Understanding, then, that various elementary bodies, when volatilized in a flame and examined by a spectroscope, give spectra distinguished by bright-colored lines, soda by yellow, strontia by red, etc., the reader is ready to grasp the next idea in the investigation.

If the light coming from such a source as a mass of white-hot iron, which is free from all Fraunhofer lines, be passed through a flame where soda is volatilizing, before it is analyzed by the prism, instead of seeing the bright yellow lines characteristic of the soda, we shall find in their place two dark lines. In other words, the soda flame has interfered with the continuity of the spectrum of the white-hot body, and produced therein two Fraunhofer lines. If a number of substances are burning in the flame at once, we shall get in the spectrum an increased number of lines. A flame refuses to permit the passage of rays of the same kind as it emits. White light passing through a soda flame has the yellow rays sifted out of it.

It is obvious at once, from such considerations, that we can ascertain the constitution of the sun, both as regards his physical character and chemical composition. From the fact that the lines in his spectrum are dark, we infer that he has an intensely hot solid or fluid nucleus, emitting light, and surrounded by an atmosphere of flame in which there are many volatilized bodies. If he were solely an ignited gas or flame, the lines of his spectrum would be bright instead of dark.

As regards chemical composition, it is only necessary to ascertain what elementary substance can produce lines corresponding to those in the solar spectrum. We can then at once be sure that those bodies exist in the luminary. The presence of iron, sodium, and a variety of other materials familiar to us here, has thus been proved.

The reader will at once perceive what an important bearing these facts have on the construction and unity of the solar system. We have shown that on two members of it — the sun and the earth — the same substances are found, and we may, therefore, infer that all the rest are similarly composed — for no other two, at first sight, seem more unlike. The sun, and all his attending

planets, with their satellites, are composed of the self-same elements.

In this place, it is interesting to refer to a theory by which such facts may be accounted for, and the reason of the similarity shown. The nebular hypothesis assumes that our solar system was at one time a gaseous mass, extending beyond the orbit of the farthest planet, Neptune. Its composition was necessarily uniform throughout, for the tendency of gases to diffuse into one another, or intermingle, would have free play. In this nebula the temperature was very high, for the elementary bodies were in a vaporous state in it, just as they are at present in the sun. But as soon as the mass commenced to lose its heat, there were established currents and a general movement of rotation, and on the exterior a shell, or, rather, equatorial band of condensed materials began to form. The cooling and consequent contraction still continuing, the band was left behind, but it sooner or later broke, in one or more places, and aggregated into one or more globular masses, which continued their rotation as planets.

The same thing occurring several times in succession, and rings of molten matter being left behind by the contracting gaseous mass, as it lost its heat, eventually all the planets, as we now see them, were formed, and the remainder of the nebula is the sun, still preserving the form partly of ignited gas, and partly, probably, of a liquid or solid. It is, however, even now radiating its heat away and cooling, though slowly. After, perhaps, giving off a few more planets, whose orbits will not exceed in diameter his present size, the sun, according to the hypothesis, will be no longer visibly hot, and life on the planets will come to an end.

This celebrated hypothesis has been very freely discussed, and has received much adverse criticism. Many strong objections have been urged against it, but the spectroscope confirms it. The reader will not be able to appreciate the full value of this support, until the constitution of the nebulæ visible in the heavens has been spoken of. It will, therefore, be reserved for that place.

But let us not confine ourselves in these observations to our own solar system. Let us see whether this little instrument, which is scarcely anything more than a small triangular piece of glass, will not enable us to establish a relationship with more distant bodies than the sun and planets, — with other solar systems far away in the abysses of space.

To the naked eye, there appear scattered over the sky at night a multitude of stars of various colors. Even in our best telescopes they are only glittering points, and no glimpse of their chemical constitution could be presented before the spectroscope was applied to investigate them. We were satisfied that they shone by their own light, that they were suns, that they presented many analogies to our solar system, and also many dissimilarities.

The stars, both single and double, when examined by the spectroscope, are observed to contain substances well known to us. One of them, Arcturus, closely resembles our sun, as has been shown by Rutherford. At once we perceive a fellowship between

them and our own earth, and are led to the noble idea that Nature constructs everywhere out of the same materials. Bodies, so distant that the astronomer fails to give us an idea of their remoteness, are brought, as it were, into our grasp, and are analyzed with certainty. We recognize the same elements in them that compose the soil we tread, the water we drink, the air we breathe.

And what are these materials? Chemists enumerate to us sixty-eight elementary bodies, that is, substances not composed of anything else, and that cannot be further decomposed. Such are the gases: oxygen, nitrogen, hydrogen, etc.; the liquids: mercury, bromine, etc.; the solids: sulphur, iron, gold, etc. One is fifteen times lighter than the air, another twenty-one times as heavy as water. Truly, Nature has variety enough to choose from, for out of sixty-eight elements how many combinations may not be made? But this very variety creates at once a suspicion that the ultimate elementary bodies are not in fact so numerous.

Among the reasons for doubting the multiplicity of elementary bodies, it may be stated: 1. That many of them are so nearly identical that it requires a good chemist to distinguish one from another. 2. That in our own times a number of elements have been stricken from the list, having been found to be compound bodies. 3. That by quite trivial means one elementary substance may be made to assume a form having properties totally distinct from those it originally possessed. 4. That we can form, from two or more elements, bodies which have the attributes of elements, a case in point being cyanogen. 5. That the infinite variety of organic substances, such as the various tissues of the bodies of animals and plants, diverse as they are, all are formed principally from four elementary bodies. A multitude more of such arguments might be advanced; but the general conclusion which they indicate can be summed up in a line. All the sixty-eight elements may be compounds of perhaps only two or three elements, — may even be modifications of a single type of matter. But any further consideration of this part of the subject would lead us into an examination of the nature of matter, and its atomic constitution, and with that we have not room to deal.

But we will penetrate yet a step further into space. The stars, it has been stated, are exceedingly remote. Let us examine bodies so distant that the stars are near neighbors compared with them. Clusters, resolvable nebulæ, true nebulæ, shall carry us as far from the earth into space as the eye can see.

To the naked eye, or in a telescope of low magnifying power, there are visible in the sky certain patches of diffused light, differing in appearance from the glittering stars. Some, when examined with a higher power, are seen to be resolved into an aggregation of stars; some, by the use of the highest attainable magnifying power, on the finest nights, are with difficulty resolved, while some resist every attempt. It is with the last that we are more particularly concerned.

The great reflecting telescope of Lord Rosse is well known. It is six feet in aperture, and fifty-four feet in focal length. By its

aid, nebulæ that had, up to his time, been unresolved, were separated into stars; and from this circumstance the argument was advanced that all nebulæ would yield to a sufficient increase of power, and be demonstrated to consist of stars, which, while in reality separated by immense distances, yet seem so closely packed together that their light is blended into one mass.

We have spoken of solar systems; there are, according to these statements, also stellar systems, where, instead of a sun and planets, there are groups of suns. Our sun belongs to such a group of resolvable nebulæ, the stars that we see individualized, and those of the milky way, being his companions.

Seen at a great enough distance, our nebular or stellar system would present a flattened or lima-bean-like shape, somewhat elliptical from one point of view, and like a narrow band from another. Is this group arrangement the only form in which luminous matter is found in the universe?

Here, again, the power of means apparently trivial, but rightly applied, is shown. Once more the prism of glass solves a question, which hundreds of thousands of dollars expended in telescopes could not have settled. On applying the spectroscope to the investigation of the irresolvable nebulæ, Huggins finds that some of them present the spectra characteristic of an ignited gas, that is, of a flame. The Fraunhofer lines in that case are, as we have said, bright instead of dark, as in the solar spectrum, and the evidence is of a very tangible and unmistakable kind.

There are, then, in space, masses of ignited gaseous matter of prodigious extent, shining by their own light, containing no star, and resembling the nebulæ, which the nebular hypothesis declares to have been the original state of our solar system.

Now we can appreciate the assistance which the spectroscope has lent in establishing that noble conception of Herschel and Laplace. It has demonstrated the unity of the solar system by establishing the existence throughout it of the same elements; it has shown the same unity in the materials of the universe; and lastly, it fortifies us in the belief that the theoretical conception is in process of realization before our eyes; that we may see worlds in the act of formation. The spectroscope has also a bearing on a great geological hypothesis: the former heated state of our globe. Geologists assert, from the presence in high latitudes of fossil remains of tropical plants, that the earth was once in a molten condition; that it cooled gradually, and at one time reached such a temperature that the internal heat sufficed to maintain a warm climate on every part. The polar regions were not then dependent on the sun for their supply of heat, but needed that luminary only for light. Vegetation was somewhat like that of a hot-house in the north in winter, with plenty of heat, but lacking light for part of the year.

By this hypothesis, a great variety of facts, such as the formation of some mountain ranges, may be satisfactorily explained. For example, when the heated mass of the earth was cooling it was also shrinking, but as soon as an inflexible crust had formed over the liquid ball, that exterior could no longer gradually

diminish in circumference, but was forced to pucker into ridges, just as we see in the case of an apple drying up. The apple assumes a wizened appearance; so did the earth. The wrinkles are mountain chains.

The spectroscopic confirmation of these ideas, though indirect, follows necessarily from the support which that instrument lends to the nebular hypothesis. If the earth was once an ignited gas, it is certain that it also presented subsequently a molten form. And its geometrical shape, that of an oblate spheroid, the figure naturally assumed by a rotating liquid mass, is an important link in the chain of evidence.

Another reflection naturally suggests itself to any one thinking about these matters. We know that heat was the force concerned in keeping the materials of our solar system in the gaseous state, for by its aid we can again bring most of them into that form. The escape of heat was the cause of the solidification of the present crust of the earth. Where has all that immense amount of heat gone to?

It escaped altogether as radiant heat, moving in straight lines. Is it lost in the abysses of the universe, or is it somewhere collected together to melt worn-out worlds into nebulæ again, and cause them to run again the course they have before pursued? Can we discover the scheme by which perishing systems are replaced by new ones, and the grand East Indian idea, of a multiplicity of worlds in an infinity of time, realized? How, when the light of our sun has faded out, shall our solar system be revivified, and re-supplied with the force it has lost? These are questions that remain to be solved. We are satisfied that matter and force are eternal; but what their laws of distribution and operation in space and time are, the intellect of man has yet to discover.

And if there has been a gradual formation of planets within our solar system, beginning at its confines, one after another losing its internal heat and becoming dependent on the sun for warmth, does not another thought occur to us? Has not life followed the inward march of heat? Is it not possible that there was a time when plants and animals, such as we have here, were able to exist on the exterior planets, favored by their genial heat? The last traces may not have disappeared from them. And may not the types of low forms of organized things, that inhabited this earth in early geological times, have passed inward toward the sun, where surrounding physical conditions favored them in a manner that has ceased here? Are there on Venus the radiata, mollusca, etc., belonging to our planet ages ago? Do types of life exist in the more distant planets, of some grade higher than our own? We see on the earth the migrating animals, that cannot stand the vicissitudes of summer and winter, follow the sun southward in winter, and driven before him northward in the summer. Is there in the solar system a similar obedience to heat and its effects, and an ever inward flowing tide of life? — *Galaxy.*

SPECTRUM OF THE NEBULA IN ORION.

At the meeting of the Royal Astronomical Society, March 10, 1865, Mr. Huggins observed that "the recent examination of the great nebula in Orion shows that this large and wonderful object belongs to the class of gaseous bodies. The light from this nebula resolves itself, under the refractive power of the prism, into the same three bright lines. With a narrow slit they appear exceedingly thin and well-defined. The intervals between them are dark, and in the light from no part of this nebula was any indication detected of a continuous spectrum, such as is characteristic of incandescent solid or liquid matter. Different portions of this great nebulous mass were brought successively upon the slit, but the results of minute examination showed that the whole nebula emits light, which indicates a constitution identical throughout the body. The light from one part differs from that of another in intensity alone.

"The four bright stars of the trapezium, and other stars distributed over the nebula, gave a continuous spectrum. According to Lord Rosse and Prof. Bond, the brighter parts near the trapezium consist of clustering stars. If this be the true appearance of the nebula under great telescopic power, then these discrete points of light must indicate separate and probably denser portions of the gas, and that the whole nebula is to be regarded rather as a system of gaseous bodies than as an unbroken vaporous mass. Since the usually received opinion of the enormous distances of the nebulæ has no longer any foundation to rest upon, in respect of the nebulæ which give a gaseous spectrum, it is much to be desired that proper motion should be sought for in such of them as are suitable for this purpose. If the gaseous matter of these objects represented the 'nebulous fluid,' out of which, according to the hypothesis of Sir William Herschel, stars are to be elaborated, we should expect a spectrum on which the groups of bright lines were as numerous as the dark lines due to absorption found in the spectra of the stars. If the three bright lines be supposed to indicate matter in its most primary forms, still we should expect to find in some of the nebulæ, or in some parts of them, indication by a more complex spectrum, of an advance in the formation of the separate elementary bodies which exist in the sun and in the stars. A progressive formation of some kind is, however, suggested by the presence in many of the nebulæ of a nucleus, the spectrum of which indicates that it is not pure gas, but contains solid or liquid matter. It may, therefore, be, that nebulæ which have little indication of resolvability, and yet give a continuous spectrum, such as the Great Nebula in Andromeda, are not clusters of suns, but gaseous nebulæ, which, by the gradual loss of heat, or the influences of other forces, have become crowded with more condensed and opaque portions.

"So far as my observations extend at present, they suggest the opinion that the nebulæ which give a gaseous spectrum are sys-

tems possessing a structure, and a relation to the universe, altogether distinct from the great group of cosmical bodies to which our sun and the fixed stars belong." — *Astron. Soc. Notices.*

THE GREAT NEBULA OF ORION.

It does not always happen that a celestial object, the physical characteristics of which are being discussed by scientific men, lends itself so admirably to our inquiry as does the great nebula of Orion at the present moment, while astronomers are — or should be — subjecting it to a searching scrutiny. And this for more reasons than one, for nebulæ we now know are by no means the very-easily-to-be-understood bodies we considered them some years ago; and Mr. Hind's announcement of their variability has lately been quite eclipsed by Mr. Huggins' discovery of their real nature.

Thus we must now at once discard the notion — a very pardonable one when we consider how it came to be held — that the glorious cluster in Perseus, or that somewhat more typical one in Hercules, may be taken as an exemplar of all our nebulæ, could we bring sufficient optical power to bear upon them. The astonishing variability of some nebulæ, to which we have before alluded, was certainly enough to set astronomers to work with their telescopes, if the spectroscope had not been brought to bear on the inquiry; and indeed the magnificent refractor of Pulkowa had already revealed to Dr. Winnike's practiced eye indications in this very nebula, which led him to infer that their physical constitution differed widely from that heretofore assigned to them.

But, in our own country, evidence has not been altogether wanting on the point. About this time last year, we drew attention to a communication made to the Astronomical Society, by Messrs. Stone and Carpenter, relative to two of the best drawings extant of the glorious object now more particularly in question. From Prof. Bond's rejoinder to this and other telescopic observations with which we are acquainted, we can scarcely come to any other conclusion than that changes to a greater or less extent are actually going on in the position of different portions of the nebula, if not even in its brightness.

We have referred in a former article to Mr. Huggins' first paper presented to the Royal Society on the gaseous nature of nebulæ, in which, out of eight nebulæ examined, six present little indication of resolvability. In a subsequent paper, to which we now wish to call attention, this question of resolvability is further discussed.

The other two nebulæ which gave a spectrum indicative of matter in the gaseous form are 57 M, the annular nebula in Lyra, and 27 M, the Dumb-bell nebula. The results of the examination of these nebulæ with telescopes of great power, is regarded by some to be in favor of their consisting of clustering stars. It was therefore of importance to determine, by the observation of other objects, whether any nebulæ which have been certainly resolved give a spectrum which shows the source of light to be glowing

gas. The examination of easily resolved clusters by spectrum analysis was a sure means of doing this.

2 and 15 M, and 4678 and 4670 in Sir John Herschel's catalogue, both bright clusters, were chosen. Both these clusters gave a continuous spectrum.

The Great Nebula in the Sword-handle of Orion was next examined. The telescopic observations of this nebula seem to show that it is suitable for observation, as a crucial test of the correctness of the usually received opinion that the resolution of a nebula into bright points is a certain and trustworthy indication that the nebula consists of stars. Would the brighter portions of the nebula adjacent to the trapezium which have been resolved, according to Sir John Herschel and others, present the same spectrum as the fainter and outlying portions? In the brighter parts, would the existence of closely-aggregated "stars" be revealed to us by a continuous spectrum, in addition to that of the true gaseous matter? These are suggestive questions, which it was desirable to answer.

The light from the brightest parts of the nebula near the trapezium was resolved into the three bright lines, to which we have before drawn attention. These three lines, indicative of a gaseous constitution, appeared, when the slit of the apparatus was made narrow, very sharply defined, and free from nebulosity; the intervals between the lines were quite dark.

When either of the four bright stars of the trapezium was brought upon the slit, a continuous spectrum of considerable brightness, and nearly linear (the cylindrical lens of the apparatus having been removed), was seen, together with the bright lines of the nebula, which were of considerable length, corresponding to the length of the opening slit. A fifth star γ' and a sixth α' are seen in the telescope, but the spectra of these are too faint for observation.

The positions in the spectra of α, β, γ, δ trapezii, which correspond to the positions in the spectrum of the three bright lines of the nebula, were carefully examined, but in no one of them were dark lines of absorption detected.

The part of the continuous spectra of the stars α, β, γ, near the position in the spectrum of the brightest of the bright lines of the nebula, appeared, on a simultaneous comparison, to be more brilliant than the line of the nebula, but in the case of γ the difference in brightness was not great. The corresponding part of δ was perhaps fainter. In consequence of this small difference of brilliancy, the bright lines of the adjacent nebula appeared to cross the continuous spectra of γ and δ trapezii.

Other portions of the nebula were then brought successively upon the slit; but, throughout the whole of those portions of the nebula which are sufficiently bright for this method of observation, the spectrum remained unchanged, and consisted of the three bright lines only. The whole of this great nebula, as far as it lies within the power of an eight-inch achromatic, emits light identical in character. The light from one part differs from the light of another in intensity alone.

The clustering "stars" of which, according to Lord Rosse and Professor W. C. Bond, the brighter portions of this nebula consist, cannot be supposed to be invisible in the spectrum apparatus because of their faintness, an opinion which is probably correct of the minute and widely separated "stars" seen in the Dumb-bell Nebula. The evidence afforded by the largest telescopes appears to be, that the brighter parts of the nebula in Orion consist of a "mass of stars;" the whole, or the greater part of the light from this part of the nebula, must therefore be regarded as the united radiation of these numerous stellar points. Now it is this light which, when analyzed by the prism, reveals to us its gaseous source; and the bright lines indicative of gaseous constitution are free from any trace of a continuous spectrum, such as that exhibited by all the brighter stars hitherto examined.

The conclusion is obvious, that the detection in a nebula of minute, closely associated, points of light, which observation has hitherto been considered as a certain indication of a stellar constitution, can no longer be accepted as a trustworthy proof that the object consists of true stars. These luminous points, in some nebulæ, at least, must be regarded as themselves gaseous bodies, denser portions, probably, of the great nebulous mass, since they exhibit a constitution which is identical with the fainter and outlying parts which have not been resolved. These nebulæ are shown by the prism to be enormous gaseous systems; and the conjecture appears probable that their apparent permanence of general form is maintained by the continual motions of these denser portions, which the telescope reveals as lucid points.

Mr. Huggins, in his very suggestive paper, does not stop here; he points out that the proper motion of this nebula has not yet been inquired into, because everybody, looking upon them as irresolvable clusters, thought them infinitely remote. Now, however, that we know that they are not clusters of "stars," properly so called, it is possible that they may be much nearer to us than we imagine. The strange variability of the fifth and sixth stars in the trapezium should not here be passed over in silence, while we remark that Bond's latest observations tend to show that the proper motion of the nebula cannot be different from that of the stars in the trapezium.

At all events, it is to be hoped that the present favorable position of Orion will secure for the glorious nebula a searching scrutiny with the largest instruments. This can scarcely fail to supply us with new facts. In the meantime, what of the various shapes assumed by the gaseous nebulæ, from the brilliant and most irregular one of Orion to the faintest and most perfectly rounded planetary one? Must we look upon them as other evidences of celestial dynamics?

M. Otto Struve, the eminent director of the Pulkowa Observatory, and Father Secchi, have recently been examining the nebula with the magnificent nine-inch Merz of the Roman College. The fact of changes having taken place is put beyond doubt by their observations. — *Reader*.

SPECTRUM OF COMET I., 1866.

Mr. William Huggins, F.R.S., examined the light both of the nucleus and of the coma of the small telescopic comet which was visible during a part of January last, and which is catalogued by the astronomers as Comet I., 1866, by the aid of the spectrum apparatus with which he made his well-known observations on the spectra of the nebulæ. His observations have led him to the conclusions that the nucleus of that comet is self-luminous, and that it consists of gaseous matter in a state of incandescence, but that the coma is not self-luminous, and that the reflected light by which the coma was rendered visible to us was the light of the sun. The spectrum of the nucleus, like the spectra of several of the nebulæ previously examined by Mr. Huggins, consisted of but one bright line, corresponding in refrangibility with the brightest of the lines of nitrogen. The exact similarity between the spectrum of this comet and spectra of the nebulæ in question, implies the existence of some very close relation between cometary and nebulous matter, while the identity of the single line presented by these spectra with one of the nitrogen lines would seem to suggest the hypothesis that nitrogen is not an elementary substance, but a compound one, and that it is of some one of the several constituents, which thus go to make up what we know as nitrogen, that this nebulous and cometary matter consists. — *Mechanics' Magazine, March,* 1866.

SPECTRUM OF SIRIUS.

Father Secchi has just announced that the space in the spectrum of Sirius, which is included between the extreme red and the first band, is "divided by small bands, sensibly equi-distant," which small bands are of such extreme regularity as to give to the spectrum a "channelled" appearance. He counted twenty-eight of these small bands, nothing similar to which has yet been observed in any other spectrum.

SPECTRUM OF SHOOTING STARS.

Mr. A. S. Herschel has recently observed the spectrum of a shooting star. It appeared near Capella, and was almost as brilliant as that star. He followed it for more than a second in its rather slow motion, and ascertained that its spectrum was as continuous a spectrum as that of Capella, and a little more extended, and, therefore, that it consisted of a solid or liquid substance, and not of a gas or incandescendent vapor, as Mr. Huggins has suggested with regard to some nebulæ.

He has observed seventeen meteors, coming to the conclusion that "if the problem of chemically analyzing the substance of luminous meteors by means of their light spectra is not yet fairly solved, it is at all events pretty certain that the metal sodium produces the most enduring light of the much admired trains of the August meteors; and that at least one other mineral substance

(either potassium, sulphur, or phosphorus) lends its aid, but in a much less remarkable degree, to produce the same luminous trains."—*Reader.*

RESULTS OF SPECTRUM ANALYSIS APPLIED TO THE HEAVENLY BODIES.

The following are extracts from a lecture delivered before the British Association, at Nottingham, Aug. 23, 1866, by William Huggins, F.R.S.:—

"I bring before you some additions to our knowledge in the department of astronomy, which have followed from a comparatively recent discovery. The researches of Kirchhoff have placed in the hands of the astronomer a method of analysis which is specially suitable for the examination of the heavenly bodies. So unexpected and important are the results of the application of spectrum analysis to the objects in the heavens, that this method of observation may be said to have created a new and distinct branch of astronomical science.

"Physical astronomy, the imperishable and ever-growing monument to the memory of Newton, may be described as the extension of terrestrial dynamics to the heavens. It seeks to explain the movements of the celestial bodies on the supposition of the universality of an attractive force, similar to that which exists upon the earth.

"The new branch of astronomical science, which spectrum analysis may be said to have founded, has for its object to extend the laws of terrestrial physics to the other phenomena of the heavenly bodies; and it rests upon the now established fact, that matter of a nature common to that of the earth, and subject to laws similar to those which prevail upon the earth, exists throughout the stellar universe.

"The peculiar importance of Kirchhoff's discovery to astronomy becomes obvious, if we consider the position in which we stand to the heavenly bodies. Gravitation and the laws of our being do not permit us to leave the earth; it is therefore by means of light alone that we can obtain any knowledge of the grand array of worlds which surround us in cosmical space. The star-lit heavens is the only chart of the universe we have, and in it each twinkling point is the sign of an immensely vast, though distant, region of activity.

"Hitherto the light from the heavenly bodies, even when collected by the largest telescopes, has conveyed to us but very meagre information, and in some cases only of their form, their size, and their color. The discovery of Kirchhoff enables us to interpret symbols and indications hidden within the light itself, which furnish trustworthy information of the chemical, and also to some extent of the physical, condition of the excessively remote bodies from which the light has emanated.

"We are indebted to Newton for the knowledge that the beautiful tints of the rainbow are the common and necessary ingredients of ordinary light. He found that when white light is made

to pass through a prism of glass, it is decomposed into the beautiful colors which are seen in the rainbow. These colors, when in this way separated from each other, form the spectrum of the light. Let this white plate represent the transverse section of a beam of white light travelling towards you. Let now a prism be interposed in its path. The beam of white light is not turned aside as a whole, but the colored lights composing it are deflected differently, each in proportion to the rapidity of its vibrations. An obvious consequence will be, that, on emerging from the prism, the colored lights which formed the white light will separate from each other, and in place of the white light which entered the prism we shall have its spectrum, that is, the colored lights which composed it, in a state of separation from each other. Wollaston and Fraunhofer discovered that when the light of the sun is decomposed by a prism, the rainbow colors which form its spectrum are not continuous, but are interrupted by a large number of dark lines. These lines of darkness are the symbols which indicate the chemical constitution of the sun. It was not until recently, in the year 1859, that Kirchhoff taught us the true nature of these lines. He himself immediately applied his method of interpretation to the dark lines of the solar spectrum, and was rewarded by the discovery that several of the chemical elements which exist upon the earth are present in the solar atmosphere.

"I present the results of the extension of this method of analysis to the heavenly bodies other than the sun. These researches have been carried on in my observatory during the last four years. In respect to a large part of these investigations, — viz., those of the moon, the planets, and fixed stars, — I have had the great pleasure of working conjointly with the very distinguished chemist and philosopher, Dr. William A. Miller. Half a century ago, Fraunhofer recognized several of the solar lines in the light of the Moon, Venus, and Mars, and also in the spectra of several stars. Recently, Donati, Janssen, Secchi, Rutherford, and the Astronomer Royal, have observed lines in the spectra of some stars. Before I describe the results of our observations, I will state, in a few words, the principles of spectrum analysis upon which our interpretation of the phenomena we have observed has been based, and also the method of observing which we have employed.

"When light which has emanated from different sources is decomposed by a prism, the spectra which are obtained may differ in several important respects from each other. All the spectra which may present themselves can be conveniently arranged in three general groups.

"1. The special character which distinguishes spectra of the first order consists, in that the continuity of the colored band is unbroken either by dark or bright lines. We learn from such a spectrum that the light has been emitted by an opaque body, and almost certainly by matter in the solid or liquid state. A spectrum of this order gives to us no knowledge of the chemical nature of the incandescent body from which light comes.

"2. Spectra of the second order are very different. These consist of colored lines of light separated from each other. From

such a spectrum we may learn much. It informs us that the luminous matter from which the light has come is in the state of gas. It is only when a luminous body is free from the molecular trammels of solidity and liquidity, that it can exhibit its own peculiar power of radiating some colored rays alone. Hence substances, when in a state of gas, may be distinguished from each other by their spectra. Each element, and every compound body that can become luminous in the gaseous state without suffering decomposition, is distinguished by a group of lines peculiar to itself.

"3. The third order consists of the spectra of incandescent solid or liquid bodies, in which the continuity of the colored light is broken by dark lines. These dark spaces are not produced by the source of the light. They tell us of vapors through which the light has passed on its way, and which have robbed the light, by absorption, of certain definite colors or rates of vibration. Such spectra are formed by the light of the sun and stars.

"Kirchhoff has shown that, if vapors of terrestrial substances come between the eye and an incandescent body, they cause groups of dark lines; and, further, that the group of dark lines produced by each vapor is identical in the number of the lines and in their position in the spectrum with the group of bright lines of which its light consists when the vapor is luminous.

"It is evident that Kirchhoff, by this discovery, has furnished us with the means of interpreting the dark lines of the solar spectrum. For this purpose it is necessary to compare the bright lines in the spectra of the light of terrestrial substances, when in the state of gas, with the dark lines of the solar spectrum. When a group of bright lines coincides with a similar group of dark lines, then we know that the terrestrial substance producing the bright lines is present in the atmosphere of the sun; for it is this substance, and this substance alone, which, by its own peculiar power of absorption, can produce that particular group of dark lines. In this way Kirchhoff discovered the presence of several terrestrial elements in the solar atmosphere.

"*Methods of Observation.* — I now pass to the special methods of observation by which, in our investigations, we have applied these principles of spectrum analysis to the light of the heavenly bodies. I may here state that several circumstances unite to make these observations very difficult and very irksome. In our climate, on few only even of those nights in which the stars shine brilliantly to the naked eye, is the air sufficiently steady for these extremely delicate observations. Further, the light of the stars is feeble. This difficulty has been met, in some measure, by the employment of a large telescope. The light of a star falling upon the surface of an object-glass of eight inches aperture is gathered up and concentrated at the focus into a minute and brilliant point of light.

"Another inconvenience arises from the apparent movement of the stars, caused by the rotation of the earth, which carries the astronomer and his instruments with it. This movement was counteracted by a movement given, by clockwork, to the telescope, in the opposite direction. In practice, however, it is not easy to

retain the image of a star for any length of time exactly within the jaws of a slit only the 1-300th of an inch apart. By patient perseverance these difficulties have been overcome, and satisfactory results obtained. We considered that the trustworthiness of our results must rest chiefly upon direct and simultaneous comparison of terrestrial spectra with those of celestial objects. For this purpose we contrived the apparatus which is represented in the diagram.

"By this outer tube the instrument is adapted to the eye-end of the telescope, and is carried round with it by the clock motion. Within this outer tube a second tube slides, carrying a cylindrical lens. This lens is for the purpose of elongating the round point-like image of the star into a short line of light, which is made to fall exactly within the jaws of a nearly-closed slit. Behind the slit, an achromatic lens (and at the distance of its own focal length) causes the pencils to emerge parallel. They then pass into two prisms of dense flint glass. The spectrum which results from the decomposition of the light by the prisms is viewed through a small achromatic telescope. This telescope is provided with a micrometer screw, by which the lines of the spectra may be measured.

"The light of the terrestrial substances, which are to be compared with the stellar spectra, is admitted into the instrument in the following manner:—

"Over one-half of the slit is fixed a small prism, which receives the light reflected into it by the movable mirror placed over the tube. The mirror faces a clamp of ebonite, provided with forceps to contain fragments of the metals employed. These metals are rendered luminous in the state of gas by the intense heat of the sparks from a powerful induction coil. The light from the spark, reflected into the instrument by means of the mirror and the little prism, passes on to the prisms in company with that from the star. In the small telescope, the two spectra are viewed in juxtaposition, so that the coincidence and relative positions of the bright lines in the spectrum of the spark with dark lines in the spectrum of the star, can be accurately determined.

"*Moon and Planets.*—I now pass to the results of our observations.

"I refer, in a few words only, to the moon and planets. These objects, unlike the stars and nebulæ, are not original sources of light. Since they shine by reflecting the sun's light, their spectra resemble the solar spectrum; and the only indications in their spectra which may become sources of knowledge to us are confined to any modifications which the solar light may have suffered, either in the atmospheres of the planets, or by reflection at their surfaces.

"*Moon.*—On the moon, the results of our observations have been negative. The spectra of the various parts of the moon's surface, when examined under different conditions of illumination, showed no indication of an atmosphere about the moon. I also watched the spectrum of a star, as the dark edge of the moon advanced towards the star, and then occulted it. No signs of a lunar atmosphere presented themselves.

"*Jupiter.*—In the spectrum of Jupiter, lines are seen, which indicate the existence of an absorptive atmosphere about this planet. In this diagram these lines are presented as they appeared when viewed simultaneously with the spectrum of the sky, which, at the time of observation, reflected the light of the setting sun. One strong band corresponds with some terrestrial atmospheric lines, and probably indicates the presence of vapors similar to those which are about the earth. Another band has no counterpart amongst the lines of absorption of our atmosphere, and tells us of some gas or vapor which does not exist in the earth's atmosphere.

"*Saturn.*—The spectrum of Saturn is feeble, but lines similar to those which distinguish the spectrum of Jupiter were detected. These lines are less strongly marked in the ansæ of the rings, and show that the absorptive power of the atmosphere about the rings is less than that of the atmosphere which surrounds the ball. A distinguished foreigner, present at the meeting, Janssen, has quite recently found that several of the atmospheric lines in this part of the spectrum are produced by aqueous vapor. It appears to be very probable that aqueous vapor exists in the atmospheres of Jupiter and Saturn.

"*Mars.*—On one occasion some remarkable groups of lines were seen in the more refrangible part of the spectrum of Mars. These may be connected with the source of the red color which distinguishes this planet.

"*Venus.*—Though the spectrum of Venus is brilliant, and the lines of Fraunhofer were well seen, no additional lines affording evidence of an atmosphere about Venus were detected. The absence of lines may be due to the circumstance that the light is probably reflected, not from the planetary surface, but from clouds at some elevation above it. The light which reaches us in this way, by reflexion from clouds, would not have been exposed to the absorbent action of the lower and denser strata of the planet's atmosphere.

"*The Fixed Stars.*—The fixed stars, though immensely more remote, and less conspicuous in brightness than the moon and planets, yet because they are original sources of light, furnish us with fuller indications of their nature.

"The stars have indeed been represented as suns, each upholding a dependent family of planets. This opinion rested upon a possible analogy alone. It was not more than a speculation. We possessed no certain knowledge from observation of the true nature of those remote points of light. This long and earnestly-coveted information is at last furnished by spectrum analysis. We are now able to read in the light of each star some indications of its nature. I will take first the spectra of two bright stars which we have examined with great care.

"The upper one represents the spectrum of Aldebaran, and the other that of Betelgeux, the star marked *a* in the constellation of Orion.

"The positions of all these dark lines, about eighty in each star, were determined by careful and repeated measures. These

measured lines form but a small part of the numerous fine lines which may be seen in the spectra of these stars.

"Beneath the spectrum of each star are represented the bright lines of the metals which have been compared with it. These terrestrial spectra appeared in the instrument as you now see them upon the screen, in juxtaposition with the spectrum of the star. By such an arrangement, it is possible to determine with great accuracy whether or not any of these bright lines actually coincide with any of the dark ones. For example: —

"This closely double line is characteristic of sodium. You see that it coincides, line for line, with a dark line similarly double in the star. The vapor of sodium is therefore present in the atmosphere of the star, and sodium forms one of the elements of the matter of this brilliant but remote star.

"These three lines in the green are produced, so far as we know, by the luminous vapor of magnesium alone. These lines agree in position exactly, line for line, with three dark stellar lines. The conclusion, therefore, appears well founded, that another of the constituents of this star is magnesium.

"Again, there are two strong lines peculiar to the element hydrogen; one line has its place in the red part of the spectrum, the other at the blue limit of the green. Both of these correspond to dark lines of absorption in the spectrum of the star. Hydrogen, therefore, is present, in the star.

"In a similar way, other elements, among them bismuth, antimony, tellurium, and mercury, have been shown to exist in the star.

"Now, in reference to all these elements, the evidence does not rest upon the coincidence of one line, which would be worth but little, but upon the coincidence of a group of two, three, or four lines, occurring in different parts of the spectrum. Other corresponding lines are probably also present, but the faintness of the star's light limited our comparisons to the stronger lines of each element.

"What elements do the numerous other lines in the star represent? Some of them are probably due to the vapors of other terrestrial elements, which we have not yet compared with these stars. But may not some of these lines be the signs of primary forms of matter unknown upon the earth? Elements new to us may here show themselves, which form large and important series of compounds, and therefore give a special character to the physical conditions of these remote systems. In a similar manner the spectra of terrestrial substances have been compared with several other stars. Five or six elements have been detected in Betelgeux. Ten other elements do not appear to have place in the constitution of this star.

"β *Pegasi* contains	sodium, magnesium, and perhaps barium;
Sirius contains	sodium, magnesium, iron, and hydrogen;
a *Lyræ* (*Vega*) contains . .	sodium, magnesium, iron;
ρ *Pollux* contains	sodium, magnesium, iron.

About sixty other stars have been examined, all of which appear

to have some elements in common with the sun and earth, but the selective grouping of the elements in each star is probably peculiar and unique.

"A few stars, however, stand out from the rest, and appear to be characterized by a peculiarity of great significance. These stars are represented by Betelgeux and β Pegasi. The general grouping of the lines of absorption in these stars is peculiar, but the remarkable and exceptional feature of their spectra is the absence of the two lines which indicate hydrogen, one line in the red, and the other in the green. These lines correspond to Fraunhofer's C and F. The absence of these lines in some stars shows that the lines C and F are not due to the aqueous vapor of the atmosphere.

"We hardly venture to suggest that the planets which may surround these suns probably resemble them in not possessing the important element, hydrogen. To what forms of life could such planets be adapted? Worlds without water!

"It is worthy of consideration, that, with these few exceptions, the terrestrial elements which appear most widely diffused through the host of stars are precisely some of those which are essential to life, such as it exists upon the earth, — namely, hydrogen, sodium, magnesium, and iron. Besides, hydrogen, sodium, and magnesium represent the ocean, which is an essential part of a world constituted like the earth.

"We learn from these observations, that, in plan of structure, the stars, or at least the brightest of them, resemble the sun. Their light, like that of the sun, emanates from intensely white-hot matter, and passes through an atmosphere of absorbent vapors. With this unity of general plan of structure, there exists a great diversity amongst the individual stars. Star differs from star in chemical constitution. May we not believe that the individual peculiarities of each star are essentially connected with the special purpose which it subserves, and with the living beings which may inhabit the planetary worlds by which it may possibly be surrounded?

"When we had obtained this new information respecting the true nature of the stars our attention was directed to the phenomena which specially distinguish some of the stars.

"*Colors of the Stars.* — When the air is clear, especially in southern climes, the twinkling stars do not all resemble diamonds; here and there may be seen, in beauteous contrast, richly-colored gems.

"The color of the light of the stars which are bright to the naked eye is always some tint of red, orange, or yellow. When, however, a telescope is employed, in close companionship with many of these ruddy and orange stars, other fainter stars become visible, the color of which may be blue, or green, or purple.

"Now, it appeared to us to be probable that the origin of these differences of color among the stars may be indicated by their spectra.

"Since we had found that the source of the light of the stars is incandescent solid or liquid matter, it appeared to be very prob-

able that, at the time of its emission, the light of all the stars is white alike. The colors observed amongst them must then be caused by some modification suffered by the light, after its emission.

"Again, it was obvious that if the dark lines of absorption were more numerous, or stronger, in some parts of the spectrum, then those colors would be subdued in power, relatively to the color in which few lines only occur. These latter colors, remaining strong, would predominate, and give to the light, originally white, their own tints.

"These suppositions have been confirmed by observations.

"We have shown that the colors of the stars are produced by the vapors existing in their atmosphere. The chemical constitution of a star's atmosphere will depend upon the elements existing in the star, and upon its temperature.

"*Variable Stars.* — The brightness of many of the stars is found to be variable. From night to night, from month to month, or from season to season, their light may be observed to be continually changing, at one time increasing, at another time diminishing. The careful study of these variable stars, by numerous observers, has shown that their continual changes do not take place in an uncertain or irregular manner. The greater part of these remarkable objects wax and wane in accordance with a fixed law of periodic variation, which is peculiar to each.

"We have been seeking, for some time, to throw light upon this strange phenomenon, by means of observation of their spectra. If, in any case, the periodic variation of brightness is associated with physical changes occurring in the star, we might obtain some information by means of the prism. Again, if the diminution in brightness of a star should be caused by the interposition of a dark body, then, in that case, if the dark body be surrounded with an atmosphere, its presence might possibly be revealed to us by the appearance of additional lines of absorption in the spectrum of the star when at its minimum. One such change in the spectrum of a variable star we believe we have already observed.

"Betelgeux is a star of a moderate degree of variability. When this star was at its maximum brilliancy in February last, we missed a group of lines, the exact position of which we had determined with great accuracy by micrometric measurements some two years before.

"*Temporary Stars.* — With the variable stars, modern opinion would associate the remarkable phenomena of the so-called new stars which occasionally, but at long intervals, have suddenly appeared in the sky. But in no case has a permanently bright star been added to the heavens. The splendor of all these objects was temporary only, though whether they died out or still exist as extremely faint stars is uncertain. In the case of the two modern temporary stars, that seen by Mr. Hind in 1845, and the bright star recently observed in Corona, though they have lost their ephemeral glory, they still continue as stars of the tenth and eleventh magnitudes.

"The old theories respecting these strange objects must be rejected. We cannot believe with Tycho Brahe that objects so ephemeral are new creations, nor with Riccioli that they are stars brilliant on one side only, which have been suddenly turned round by the Deity. The theory that they have suddenly darted towards us with a velocity greater than that of light, from a region of remote invisibility, will not now find supporters.

"On the 12th of May last, a star of the second magnitude suddenly burst forth in the constellation of the Northern Crown. Thanks to the kindness of the discoverer of this phenomenon, Mr. Birmingham, of Tuam, I was enabled, conjointly with Dr. Miller, to examine the spectrum of this star on the 16th of May, when it had not fallen much below the third magnitude.

"The spectrum of this star consists of two distinct spectra. One of these is formed by four bright lines. The other spectrum is analogous to the spectra of the sun and stars.

"These two spectra represent two distinct sources of light. Each spectrum is formed by the decomposition of light, which is independent of the light which gives birth to the other spectrum.

"The continuous spectrum, crowded with groups of dark lines, shows that there exists a photosphere of incandescent solid or liquid matter; further, that there is an atmosphere of cooler vapors, which give rise by absorption to the groups of dark lines.

"So far, the constitution of this object is analogous to that of the sun and stars, but in addition there is the second spectrum, which consists of bright lines. There is therefore a second and distinct source of light, and this must be, as the character of the spectrum shows, luminous gas. Now the position of the two principal of the bright lines of this spectrum informs us that one of the luminous gases is hydrogen. The great brightness of these lines shows that the luminous gas is hotter than the photosphere. These facts, taken in connection with the suddenness of the outburst of light in the star, and its immediate very rapid decline in brightness from the second magnitude down to the eighth magnitude in twelve days, suggested to us the startling speculation that the star had become suddenly enrapt in the flames of burning hydrogen. In consequence, it may be, of some great convulsion, enormous quantities of gas were set free. A large part of this gas consisted of hydrogen, which was burning about the star in combination with some other element. This flaming gas emitted the light represented by the spectrum of bright lines. The increased brightness of the spectrum of the other part of the star's light, may show that this fierce gaseous conflagration had heated to a more vivid incandescence the solid matter of the photosphere. As the free hydrogen became exhausted, the flames gradually abated, the photosphere became less vivid, and the star waned down to its former brightness.

"We must not forget that light, though a swift messenger, requires time to pass from the star to us. The great physical convulsion, which is new to us, is already an event of the past with respect to the star itself. For years the star has existed under the new conditions which followed this fiery catastrophe.

"*Nebulæ.*—I pass now to objects of another order.

"When the eye is aided by a telescope of even moderate power, a large number of faintly luminous patches and spots come forth from the darkness of the sky, which are in strong contrast with the brilliant but point-like images of the stars. A few of these objects may be easily discerned to consist of very faint stars closely aggregated together. Many of these strange objects remain, even in the largest telescopes, unresolved into stars, and resemble feebly-shining clouds, or masses of phosphorescent haze. During the last one hundred and fifty years, the intensely important question has been continually before the mind of astronomers, 'What is the true nature of these faint, comet-like masses?'

"The interest connected with an answer to this question has much increased since Sir William Herschel suggested that these objects are portions of the primordial material out of which the existing stars have been fashioned, and, further, that in these objects we may study some of the stages through which the suns and planets pass in their development from luminous cloud.

"The telescope has failed to give any certain information of the nature of the nebulæ. It is true that each successive increase of aperture has resolved more of these objects into bright points; but, at the same time, other fainter nebulæ have been brought into view, and fastastic wisps and diffused patches of light have been seen, which the mind almost refuses to believe can be due to the united glare of innumerable suns still more remote.

"Spectrum analysis, if it could be successfully applied to objects so excessively faint, was obviously a method of investigation specially suitable for determining whether any essential physical distinction separates the nebulæ from the stars.

"I selected, for the first attempt, in August, 1864, one of the class of small but comparatively bright nebulæ.

"My surprise was very great, on looking into the small telescope of the spectrum apparatus, to perceive that there was no appearance of a band of colored light, such as a star would give; but, in place of this, there were three isolated bright lines only.

"This observation was sufficient to solve the long-agitated inquiry, in reference to this object at least, and to show that it was not a group of stars, but a true nebula.

"A spectrum of this character, so far as our knowledge at present extends, can be produced only by light which has emanated from matter in the state of gas. The light of this nebula, therefore, was not emitted from incandescent solid or liquid matter, as is the light of the sun and stars, but from glowing or luminous gas.

"It was of importance to learn, if possible, from the position of these bright lines, the chemical nature of the gas or gases of which this nebula consists.

"Measures taken by the micrometer of the most brilliant of the bright lines showed that this line occurs in the spectrum very nearly in the position of the brightest of the lines in the spectrum of nitrogen. The experiment was then made of comparing the

spectrum of nitrogen directly with the bright lines of the nebula. I found that the brightest of the lines of the nebula coincided with the strongest of the group of lines which are peculiar to nitrogen. It may be, therefore, that the occurrence of this one line only indicates a form of matter more elementary than nitrogen, and which our analysis has not yet enabled us to detect.

"In a similar manner, the faintest of the lines was found to coincide with the green line of hydrogen.

"The middle line of the three lines which form the spectrum of the nebula does not coincide with any strong line in the spectra of about thirty of the terrestrial elements. It is not far from the line of barium, but it does not coincide with it. Besides these bright lines, there was also an exceedingly faint continuous spectrum. The spectrum had no apparent breadth, and must therefore have been formed by a minute point of light. The position of this faint spectrum, which crossed the bright lines about the middle of their length, showed that the bright point producing it was situated about the centre of the nebula. Now this nebula possesses a minute but bright nucleus. We learn from this observation that the matter of the nucleus is almost certainly not in a state of gas, as is the material of the surrounding nebula. It consists of opaque matter, which may exist in the form of an incandescent fog of solid or liquid particles.

"The new and unexpected results arrived at, by the prismatic examination of this nebula, showed the importance of examining as many as possible of these remarkable bodies. Would all the nebulæ give similar spectra? Especially it was of importance to ascertain whether those nebulæ, which the telescope had certainly resolved into a close aggregation of bright points, would give a spectrum indicating gaseity.

"The observation with the prism of these objects is extremely difficult, on account of their great faintness. Besides this, it is only when the sky is very clear, and the moon is absent, that the prismatic arrangement of their light is even possible. During the last two years, I have examined the spectra of more than sixty nebulæ and clusters. These may be divided into two great groups. One group consists of the nebulæ which give a spectrum similar to the one I have already described, or else of one or two only of the three bright lines. Of the six objects examined, about one-third belong to the class of gaseous bodies. The light from the remaining forty nebulæ and clusters becomes spread out by the prism into a spectrum which is apparently continuous.

"The most remarkable, and possibly the nearest to our system, of the nebulæ presenting a ring formation, is the well-known Annular Nebula in Lyra. The spectrum consists of one bright line only. When the slit of the instrument crosses the nebula, the line consists of two brighter portions corresponding to the sections of the ring. A much fainter line joins them, which shows that the faint central portion of the nebula has a similar constitution.

"A nebula remarkable for its large extent and peculiar form, is that known as the Dumb-bell Nebula. The spectrum of this

nebula consists of one line only. A prismatic examination of the light from different parts of this object showed that it is throughout of a similar constitution.

"The most widely known, perhaps, of all the nebulæ is the remarkable cloud-like object in the sword-handle of Orion.

"This object is also gaseous. Its spectrum consists of three bright lines. Lord Rosse informs me that the bluish-green matter of the nebula has not been resolved by his telescope. In some parts, however, he sees a large number of very minute red stars, which, though apparently connected with the irresolvable matter of the nebula, are yet doubtless distinct from it. These stars would be too faint to furnish a visible spectrum.

"I now pass to some examples of the other great group of nebulæ and clusters.

"All the true clusters, which are resolved by the telescope into distinct bright points, give a spectrum, which does not consist of separate bright lines, but is apparently continuous in its light. There are many nebulæ which furnish a similar spectrum.

"I take as an example of these nebulæ, the great nebula in Andromeda, which is visible to the naked eye, and is not seldom mistaken for a comet. The spectrum of this nebula, though apparently continuous, has some suggestive peculiarities. The whole of the red and part of the orange are wanting. Besides this character, the brighter parts of the spectrum have a very unequal and mottled appearance.

"It is remarkable that the easily-resolved cluster in Hercules has a spectrum precisely similar. The prismatic connection of this cluster with the nebula in Andromeda is confirmed by telescopic observation. Lord Rosse has discovered in this cluster dark streaks or lines, similar to those which are seen in the nebula in Andromeda.

"In connection with these observations, it was of great interest to ascertain whether the broad classification afforded by the prism of the nebulæ and clusters, would correspond with the indications of resolvability furnished by the telescope. Would it be found that all the unresolved nebulæ are gaseous, and that those which give a continuous spectrum are clusters of stars?

"Half of the nebulæ which give a continuous spectrum have been resolved, and about one-third more are probably resolvable; while of the gaseous nebulæ none have been certainly resolved, according to Lord Rosse.

"*Comets.*—There are objects in the heavens which occasionally, and under some conditions, resemble closely some of the nebulæ. In some positions in their orbits some of the comets appear as round vaporous masses, and, except by their motion, cannot be distinguished from nebulæ. Does this occasional general resemblance indicate a similarity of nature? If such be the case, if the material of the comets is similar to that of the nebulæ, then the study of the wonderful changes which comets undergo in the neighborhood of the sun may furnish useful information for a more correct interpretation of the structure and condition of the nebulæ. In 1864, Donati found that the spectrum of a comet, visible in that year, consisted of bright lines.

"Last January a small telescopic comet was visible. It was a nearly circular, very faint, vaporous mass. Nearly in the centre, a small and rather dim nucleus was seen. When this object was viewed in the spectroscope, two spectra were distinguished: — a very faint continuous spectrum of the coma, showing that it was visible by reflecting solar light: — about the middle of this faint spectrum a bright point was seen. This bright point is the spectrum of the nucleus, and shows that its light is different from that of the coma. This short bright line indicates that the nucleus of this comet was self-luminous, and, further, the position of this line of the spectrum suggests that the material of the comet was similar to the matter of which the gaseous nebulæ consist.

"*Measures of the Intrinsic Brightness of the Nebulæ.* — It appeared to me that some information of the nature of the nebulæ might be obtained from observations of another order. If physical changes, of the magnitude necessary for the conversion of the gaseous bodies into suns, are now in progress in the nebulæ, surely, this process of development would be accompanied by marked changes in the intrinsic brightness of their light, and in their size.

"Now, since the spectroscope shows these bodies to be continuous masses of gas, it is possible to obtain an approximate measure of their real brightness. It is known that as long as a distant object remains of sensible size, its brightness remains unaltered. By a new photometric method, I found the intrinsic intensity of the light of three of the gaseous nebulæ, in terms of a sperm candle burning at the rate of 158 grains per hour: —

Nebula No. 4,628	$\frac{1}{1508}$**th part of the intensity of the candle.**			
Annular Nebula Lyra	$\frac{1}{6032}$**d**	"	"	"
Dumb-bell Nebula	$\frac{1}{19604}$**th**	"	"	"

"These numbers represent, not the apparent brightness only, but the true brightness of these luminous masses, except so far as it may have been diminished by a possible power of extinction existing in cosmical space, and by the absorption of our atmosphere. It is obvious that similar observations, made at considerable intervals of time, may show whether the light of these objects is undergoing increase or diminution, or is subject to a periodic variation.

"If the Dumb-bell Nebula, the feeble light of which is not more than the one-twenty-thousandth part of that of a candle, be, in accordance with popular theory, a sun-germ, then it is scarcely possible to put into an intelligible form the enormous number of times by which its light must increase, before this faint nebula, feebler now in its glimmering than a rushlight, can rival the dazzling splendor of our sun.

"*Measures of the Nebulæ.* — Some of the nebulæ are sufficiently

defined in outline to admit of accurate measurement. By means of a series of micrometric observations, it will be possible to ascertain, whether any considerable alteration in size takes place in nebulæ.

"*Meteors.*—Mr. Alexander Herschel has recently succeeded in subjecting another order of the heavenly bodies to prismatic analysis. He has obtained the spectrum of a bright meteor, and also the spectra of some of the trains which meteors leave behind them. A remarkable result of his observations appears to be that sodium in the state of luminous vapor is present in the trains of most meteors.

"*Conclusion.*—In conclusion, the new knowledge, that has been gained from these observations with the prism, may be summed up as follows: —

"1. All the brighter stars, at least, have a structure analogous to that of the sun.

"2. The stars contain material elements common to the sun and earth.

"3. The colors of the stars have their origin in the chemical constitution of the atmospheres which surround them.

"4. The changes in brightness of some of the variable stars are attended with changes in the lines of absorption of their spectra.

"5. The phenomena of the star in Corona appear to show that, in this object at least, great physical changes are in operation.

"6. There exist in the heavens true nebulæ. These objects consist of luminous gas.

"7. The material of comets is very similar to the matter of the gaseous nebulæ, and may be identical with it.

"8. The bright points of the star-clusters may not be in all cases stars of the same order as the separate bright stars.

"It may be asked, What cosmical theory of the origin and relations of the heavenly bodies do these new facts suggest? It would be easy to speculate, but it appears to me that it would not be philosophical to dogmatize, at present, on a subject of which we know so very little. Our views of the universe are undergoing important changes. Let us wait for more facts, with minds unfettered by any dogmatic theory, and therefore free to receive the obvious teaching, whatever it may be, of new observations."

GEOLOGY.

ON THE RELATIONS OF GEOLOGY AND PALÆONTOLOGY.

The following are extracts from the "Reader" of June, 1865, on the occasion of the publication of Mr. T. H. Huxley's catalogue of the Jermyn-Street collection: —

Palæontology, as a science, should enable us to determine the position of unfamiliar forms, and the age of the strata in which they occur, in the sure hope that observation will verify the prediction. Mr. Huxley says that a science of geology could not exist, that we should only have a number of local chronologies, did not palæontology combine the separate results, and deduce from them general laws. When the fossils are identical at two distant places, it should follow that palæontologists are agreed as to the age they indicate. But, twenty-seven years ago, Mr. R. G. Austen threw doubt on the comfortable doctrine that two sets of identical fossils are necessarily contemporaneous and this seeming paradox has never since been quite lost sight of. It was further developed three years ago by the author of this essay, who went so far as to hint the possible coincidence in time of two or more of the great formations. These views geologists pronounced to be errors. It would have been safer to have called them only extreme. This condemnation starts from the assumption that the so-called formations represent epochs in time rather than geographical areas. This idea is perhaps a natural result of the nearly complete sequence, found to exist in the small portion of the globe as yet carefully examined. But to apply it to other parts of the earth's surface is virtually to abandon the law of uniformity of physical processes, and to revive, in a modified form, the doctrine of cataclysms. For, if identity of species proves that the beds containing them are, however far apart, necessarily of the same age, that therefore the same conditions prevailed over areas whose size finds no modern analogy (which are, in fact, now marked by great diversities), it follows that conditions so general could only have been terminated by some cause equally general, though not necessarily violent, in its operation, before a new state of things, marked by distinct organic forms, commenced. Hence unconformities, which have been demonstrated to represent longer periods than the formations which they separate, would cease to be of local import. It would be impossible to avoid regarding those separating contemporaneous strata as simultaneous, or to escape the consequent dilemma. For, the axiom that changes are gradual is admitted on both sides, and implies that the alteration of conditions, and accompanying modification of structure among

living beings, began prior to those geologica. cnanges which gave rise to the unconformity, and prove the gap; implies, further, that all this went on in some area not necessarily adjacent, but so situated as to ensure the continuity by descent of the organic forms. To admit this, seems to concede the chief point at issue; and the concession seems involved in the uncontradicted belief held by geologists, that further research will disclose more and more strata requiring to be "intercalated" between those of existing classifications. Geologically this phrase is unfortunate, though zoölogically correct. The organic remains in such intercalated beds will, of course, fall naturally into their places in the animal series; but the insertion of the strata themselves in our tabular lists can only be done, save for limited areas, by assigning undue weight to artificial arrangements. It may not perhaps be necessary to go so far as to consider the Devonian or Permian formations as the arctic conditions coincident with a tropical Carboniferous aspect of life; but the overlap, so to speak, of physical conditions, which it seems impossible to evade, admits of no precise limitation; it must either be denied, or accepted along with all it involves.

But if the simple case, when the fossils are identical, presents so many difficulties, palæontology must, *a fortiori*, be still less reliable as a lawgiver, where distant formations yield dissimilar fossils. For zoölogy knows no law by which structural modifications can be so classified, that their relative ages may be determined by inspection; nay, those best qualified to speak with authority shrink even from asserting a progression of types from higher to lower, in time. The very theory, which sees in these modifications increasing adaptation to external conditions, deprives palæontology of all power of prediction apart from physical observation. The important caution given by Mr. Huxley (p. 40) against the assumption of identity of habits from similarity of form, points in the same direction. Lyell ("Elements," chap. ix.) points out the difficulties arising from differences of contemporaneous deposits, as, for instance, in the Levant and Red Sea, but sees no means of fixing their relative age, save where they are not far apart, and belong to the same province of terrestrial distribution; in which case, members of the common fauna and flora, accidentally preserved, might fix the relative age. A striking instance of the uncertainty in dealing with organization is offered by the Miocene formation. Its flora, as seen in Switzerland, finds its nearest living representative in the vegetation of the Southern States, and the resemblance is very strong. It must, therefore, have lived down to, co-existed with, and survived as a flora, the glacial era. Yet the most accomplished botanists vary so widely in their opinions, that the plants are by some traced eastward, by others westward from America; by others have been supposed to radiate from a centre lying between Switzerland and Western Asia. This unanimous difference, be it noted, is found after decisions have been limited to those species only, whose preservation leaves no uncertainty in their identification.

The conclusion is, that these and similar difficulties will best

be cleared up after the construction of many local chronologies, determined neither by geology alone nor by fossils alone, but with their mutual aid and correction. The generalized results of these may, probably will, lead to the discovery of laws which will render possible greater precision in the correlation of strata; but it seems more likely to anticipate this result from increased knowledge of the facts of distribution, than from any rule governing the order of structural change.

Mr. Huxley avoids the acceptance of any theory of progression founded on fossil evidence; and his reasons for so doing well illustrate the acute criticism given by Lyell ("Antiquity of Man," p. 405). Since this essay was written, Sir W. Logan's discovery, in the lower Laurentian series of Canada, of the Eozoön Canadense, and the subsequent discovery of a similar organism in Connemara, necessitate some modification of the statement that the Protozoa and Cœlenterata are unrepresented in the lowest British rocks. That fossil seems to be structurally allied to both sub-kingdoms. The negative evidence it gives does not seem to affect the progression argument. We are justified in assuming it to represent a small part only of the life, to which the enormous mass of limestone containing it is due. The other members of the series, of which we have no evidence for assuming this to be the first, exist, if at all, in some unexplored region, but more probably are lost to us by metamorphosis and resorption into the interior of the earth.

LENGTH OF GEOLOGICAL PERIODS.

All the facts of geology tend to indicate an antiquity of which we are beginning to form but a dim idea. Take, for instance, one single formation,—our well-known chalk. This consists entirely of shells, and fragments of shells, deposited at the bottom of an ancient sea far away from any continent. Such a process as this must be very slow; probably we should be much above the mark if we were to assume a rate of deposition of ten inches in a century. Now, the chalk is more than 1,000 feet in thickness, and would have required, therefore, more than 120,000 years for its formation. The fossiliferous beds of Great Britain, as a whole, are more than 7,000 feet in thickness, and many, which with us measure only a few inches, on the Continent expand into strata of immense depth; while others of great importance elsewhere are wholly wanting with us, for it is evident that during all the different periods in which Great Britain has been dry land, strata have been forming (as is, for example, the case now) elsewhere and not with us. Moreover, we must remember that many of the strata now existing have been formed at the expense of older ones; thus, all the flint gravels in the south-east of England have been produced by the destruction of chalk. This again is a very slow process. It has been estimated that a cliff 500 feet high will be worn away at the rate of an inch in a century. This may seem a low rate; but we must bear in mind that along any line of coast there are comparatively few points which are suffering at one time, and, that even on these, when a fall of cliff has taken

place, the fragments serve as a protection to the coast until they have been gradually removed by the waves. The Wealden Valley is twenty-two miles in breadth, and on these data it has been calculated that the denudation of the Weald must have required more than 150,000,000 of years. —*Lubbock's Pre-Historic Times.*

SUCCESSION OF DEPOSITS.

A paper was read before the Cambridge Philosophical Society, by Mr. H. G. Seeley, F.G.S., on the laws which have determined the distribution of Life and of Rocks. The author observed that in all denudation, whether marine or subaerial and fluviatile, the crystalline rocks which underwent this process, were again deposited in the following order: (1) Sand, (2) Clay, (3) Limestone; the second overlapping and appearing at the junction to be superposed on the first, and the third on the second. Hence these desposits, which at first sight appeared to be successive, might in reality be contemporaneous. Again, deposits were commonly assumed to be contemporaneous when they contained the same fossils; but upheaval and depression would cause the fauna of any locality to move, so that remains of the same species might be deposited necessarily in different deposits. He also considered species to be re-transmutable, and to be affected by the physical conditions under which the animal was living. Therefore, he maintained that strata could not be identified by these means, but by discovering the physical conditions under which they were deposited, and by other methods.

EPOCHS OF DEPOSIT OF GOLD.

Mr. David Forbes, in the "Geological Magazine," has a paper on the geological periods at which gold has made its appearance in the crust of our globe. He designates the two epochs of auriferous impregnation as, 1. The older or auriferous granite outburst. 2. The younger or auriferous diorite outburst. The first occurred some time between the Silurian and Carboniferous periods. The gold formations belonging to this period present themselves in Australia, Bohemia, Bolivia, Brazil, Buenos Ayres, Chili, Cornwall, Ecuador, Hungary, Mexico, New Grenada, Norway, Peru, Sweden, Ural, Wicklow; and also such deposits of gold as are found intruded as quartz nodules and veins, as if interstratified in the Cambrian and Silurian systems, which he believes to have been rendered auriferous solely from their proximity to invisible or now superficial granites. The newer outburst cut through strata containing fossils of decided Post-oölitic forms, and possibly may be as late as early Cretaceous. If Mr. Forbes is correct with respect to this comparatively recent creation, so to speak, of gold, we may hope that, whatever is the case with coal, the supply of gold may possibly be inexhaustible; as there seems no reason why fresh "outbursts" of the igneous diorite should not recur at any period.

THE SEA THE GREAT AGENT IN DENUDATION.

Mr. D. Mackintosh, in a paper on "The Sea against Rain and Frost," attempts to show the relative power of the two sets of agencies in modifying the surface of the globe. One set of observers, at the head of which stands Professor Ramsay, considers that the present form of the ground is due to sub-aerial influences; the other, led by Sir Roderick Murchison, considers that the sea has been the principal denuding or excavating agent. He adduces many facts to prove, 1. That the sea is not simply a levelling agent. 2. That rain and frost are incapable of producing cliffs. 3. That the *débris* under cliffs is due to the action of the sea. 4. That rain is incapable of abrading hard rocks. 5. That the presence and permanence of glacial markings show the limited power of atmospheric denudation. He then, in conclusion, remarks that rain and frost can only justly be regarded as supplementing the denudation effected by the sea; that their capacity to lower the earth's surface is comparatively small, unless immediately assisted by streams of sufficient transporting power; that the sea, by its laterally excavating agency, and "by uniting in itself at the same time and on the same spot a power of detaching and removing, can alone prove equivalent to the production of such a series of escarpments, cliffs, rocky pillars, terraces, headlands, etc., as those comprising the more abrupt inequalities of the earth's surface.

THE ATMOSPHERE AS A DENUDING AGENT.

Mr. J. B. Jukes and Mr. Scrope are still at issue on this point, the former contending that aqueous atmospheric agencies have most to do with the outline form of the earth, while the latter relies on volcanic influence as the most powerful and most general agency. In a letter, recently published, Mr. Jukes lays down two conclusions which, he says, are in our islands specially applicable to palæozoic districts, but which, *mutatis mutandis*, apply to rocks of all ages. They are as follows: 1. The sea has removed vast masses of rock, and left undulating surfaces, the highest points of which ultimately become the summits of mountains. 2. When these undulating surfaces are raised high into the air, they are attacked by atmospheric agencies, and hills, valleys, and plains, are gradually carved out of the rock mass below, their particular features depending on original varieties in the nature of that mass, and variations in the action of the atmospheric agencies. The latter depend largely on the variations of temperature, by which water is made to assume the different forms of vapor, water, snow, and ice. It must be recollected that the forms of our palæozoic grounds are of very ancient date, anterior to the period of the new red sandstone, and that the great denudation of the older palæozoic rocks took place even before the deposition of the old red sandstone. The time, then, during which the atmospheric agencies have been modelling the minor features, is inconceivably great. The recent temporary depression beneath the waters of the glacial

sea did little or nothing in the way of denudation, the principal effect then being the transport of blocks, or the washing about of materials already loose on the surface.— *Geolog. Mag. for May, in Popular Science Review, July*, 1866.

DATE OF THE ENGLISH CHANNEL.

Mr. Joseph Prestwich, in June, 1865, in a paper before the Geological Society, expressed the opinion that the English Channel was not the result of the last geological change, but that it existed at the time of the formation of the low-level gravels of the Somme and the Thames valleys, and probably at that of the high-level gravels. During a recent visit to the raised beach of Sangattee, he found fragments of chert in the shingle and sands, which he believed were derived from the lower cretaceous strata. Associated with them are fragments from the oölitic series of the Boulonnais, and two pebbles of red granite, probably from Cotentin. From these facts he inferred the existence of a channel open to the west, extending between France and England, anterior to the low and perhaps to the high level gravel period. Above the raised beach is a mass of chalk and flint rubble, with beds of loam, twenty to eighty feet thick, and containing land shells. He regarded this accumulation as analogous to the loess, which it resembles in its general character; and the shells found in it belong to species common in that deposit.

LOUISIANA ROCK-SALT.

The "New Orleans Times" of a recent date has the following interesting account of the wonderful deposits of salt on Petite Anse Island:—

"Perhaps the purest and most important natural deposit of salt in the world is that found on our coast, at Petite Anse Island. This deposit was referred to in French's 'Historical Recollections of Louisiana.' He quotes from the papers left by an English voyager who visited the Mississippi, or as it was then spelt, Mechacebe, in 1698–99.

"Strange as it may appear, all knowledge of this salt mine was lost among our people till after the commencement of the recent war. At that time, the residents of the interior, who were unable to procure a supply of salt otherwise, resorted thither for the purpose of boiling down the briny waters which gurgled from the base of the island elevation. This, after some investigation and experiments in well-boring, resulted in the discovery of the fact that a great portion of the island, with the exception of an upper layer of earth, was a complete crystal mass of salt. For two years, nearly the whole of the trans-Mississippi was supplied from this mine, no less than 21,000,000 pounds being taken from it in the course of three months.

"Borings have extended over a great number of acres, and the salt rock is found everywhere, from fifteen to twenty-two feet below the surface. At the point where the principal excavation was

made, the pits have been sunk through the salt to the depth of over forty feet, without any indication of reaching the bottom. It is supposed that the mine covers at least one hundred acres, and there is at present no means of ascertaining the depth of the deposits. In one week ten inexperienced hands recently got out 200,000 pounds of salt,—nearly four tons per day to each hand. What will be the product when all the contemplated mechanical agencies are put into effective operation?

"An analysis, made by the late Dr. J. L. Riddell of New Orleans, gives the following result. In one hundred parts by weight:

"Chloride of sodium (common salt)	98.88
Sulphate of lime (gypsum)	0.76
Chloride of magnesium	0.23
Chloride of calcium	0.13
Total	100.00

"Nothing else present in quantity to be appreciated. This salt is white, or colorless, and visibly consists of aggregations of irregular cubical crystals of common salt, averaging a quarter of an inch in diameter. It attracts no moisture from the atmosphere."

SALT IN IDAHO AND NEVADA.

A correspondent of the "San Francisco Bulletin," writing from Soda Springs, Idaho, says:—

"This community are at present deeply interested in the workings of the Oneida Salt Company. The grounds of this company are situated upon the Lander Cut-off Emigrant Road, about two hundred and fifty miles north from Salt Lake City, and about sixty miles north from this place. Upon their land is situated a number of large springs, with a flow of about one hundred and fifty inches of water, which, after a thorough test, have been found to yield one-third pure, fine table salt, when boiled. The company have erected works to produce 100,000 pounds per month. The expense which will necessarily accrue in the manufacture of this amount will not exceed one-quarter cent per pound, and for it there is a natural market in the mines of our sister territory, Montana, with a net profit of not less than ten cents per pound. These springs have been known for years,—emigrants passing over that road having spoken of them in the highest terms,—and a mere lack of energy has permitted them to be unappropriated. The consumption of salt in mining countries is very great, and the productions of the springs will supply the demand."

THE BASIN OF THE DEAD SEA.

M. Lartet has recently communicated to the French Academy of Sciences the results of a careful study he has made of the entire basin of the Dead Sea, in which work he has had the advantage of the direction of the Duke of Luynes.

The saltness of many Asiatic lakes, and of the Dead Sea, among

them, M. Lartet considers to be caused by the proximity of large quantities of rock-salt, or of earths containing rich saliferous deposits. Especially is this the case around the Dead Sea, where, from time immemorial, there has been known to exist the Mountain of Salt, in the Arabic of which it is believed that the name of Sodom may be recognized.

M. Lartet has carefully examined the formation of the basin of the Dead Sea, and finds that it was formed at the end of the eocene epoch, as is shown by the character of the superficial marine deposits in neighboring countries. But before this period, dislocations were produced in the submarine strata; a fracture opened in a north and south direction, which, by consecutive convulsions, prolonged itself northwards, determining, upon the shores of the Mediterranean, the formation of the mountainous ridges of Palestine, and also producing a narrow and lengthened depression which separates the high table-lands of Arabia. From this depression has sprung the commencement of the hydrographical system of this region. Thus, the Dead Sea, or Lake Asphaltites, was formed, from its origin, without any communication with the ocean.

The level of this lake, as shown by the great extent of horizontal layers of marl which have evidently been deposited at a former time, ought at a certain epoch to have been one hundred metres above its present altitude. The consequent extension of the waters of the lake is clearly shown by the sediments, which cover vast surfaces to the north and south of its actual limits. A great change must, therefore, have since occurred in the hydrographical arrangement of the country. Owing to the absence of fossils in the sediments above mentioned, it is impossible to assign the exact age of the elevation of the waters of the lake. Nevertheless, by reckoning the probable duration of the phenomena which have preceded and followed this important phase in the history of the Dead Sea, the time of its occurrence can be fixed at about the end of the tertiary or the beginning of the quaternary period.

In the diminution of the extent of the lake, M. Lartet imagines he can discover an evidence of the disappearance of former glaciers. This he thinks well accords with those traces of ancient glacier moraines, upon which Dr. Hooker believes the cedars of Lebanon now grow.

During a later period, phenomena of a different nature have otherwise altered the physical aspect of this country. At the north-east of the Dead Sea, volcanic eruptions have produced immense flows (coulées) of basaltic rock, portions of which had even overflowed into the valley of the Jordan. These eruptions made Eastern Syria at one time a volcanic district equal to that of Auvergne. Among other smaller basaltic streams, three were found bordering on the eastern edge of the Dead Sea, to the south of the little plain of Zarah.

Thermal springs, minerals similar to those bituminous emanations which have accompanied or followed the volcanic eruptions, and earthquakes still felt in this country, were stated to be the

last important phenomena, of which the basin of the Dead Sea has been the theatre. The progressive lowering of the level of the waters of the lake might be the result either of a diminished supply from the atmosphere, or of evaporation becoming more rapid, but more probably it was owing to the combined effect of these two causes.

M. Lartet concludes his paper by saying: "That the most ancient sediments in the basin of the Dead Sea do not contain any traces of fossil marine organisms, and it is therefore evident that this depression has been, from its commencement, nothing more than a reservoir of atmospheric waters, whose saltness, obtained from surrounding circumstances, is continually increased under the influence of excessive evaporation."

An idea was thrown out by M. Elie de Beaumont, which gives additional value to this statement of M. Lartet. M. Elie de Beaumont thinks that the large proportion of different salts found in the Dead Sea, Lake Van, and the Caspian Sea, appear to show that none of these sheets of water had, at any rate, derived the whole of their saltness from the ocean. He believes their saline character to proceed from local emanations of subterranean origin, and that perhaps the ocean itself owes more or less of its own saltness to a mixture of products from similar emanations.

ON THE COPPER MINES OF THE STATE OF MICHIGAN.

Mr. H. Bauerman described briefly, before the Geological Society, the different conditions under which native copper is found in the trappean belt of the Upper Peninsula of Michigan, on Lake Superior. The district in question is a narrow strip of ground, about 140 miles long, and from two to six miles in breadth, made up of alternations of compact and vesicular traps, with subordinate beds of columnar and crystalline greenstones, conformably interbedded with sandstones and conglomerates. Three different classes of deposits are known, — namely, transverse or fissure lodes in the northern district, cupriferous amygdaloids and conglomerates following the strike in the central or Portage district, and irregular concretionary lodes, also parallel to the bedding, in the southern or Ontonagon district. In the fissure-veins copper occurs either spotted through the vein-stuff, or concentrated in comparatively smooth plates, or lenticular masses, of all sizes up to 500 tons. In the Ontonagon lodes, the masses are also large, but of much more irregular forms. In the Portage district, on the other hand, only small masses are found, the great production of the mines of this region being derived from the finely-divided spots and grains interspersed through the amygdaloids and conglomerates. The author proceeded to notice the various hypotheses that may be framed for elucidating the occurrence of native copper in the Lake Superior traps. Two principal sources were indicated, the first on the supposition that protoxide of copper may have originally formed part of the felspathic component of the trap, or that the same rock may have contained sulphuretted compounds of copper mechanically intermixed; while, according to

the second view, the overlying sandstones may have contained small quantities of copper-bearing minerals, in a similar manner to the Kupferschiefer and other Permian and Triassic rocks in Europe. Supposing the trappean rocks to have been percolated by solutions carrying the products of the alteration of such minerals, it was suggested that the reduction to the metallic state was mainly produced by the action of substances containing protoxides of iron, which, by higher oxidation, have given rise to the dark-red color and the earthy ochreous substances found in the vein-matter. The causes producing the metalliferous deposits in the trap were stated to have evidently acted throughout the whole system, and the absence of copper from the compact beds is probably rather due to the absence of cavities fit for the reception of such masses, than to any difference in chemical composition.

GEOLOGICAL DESCRIPTION OF THE FIRST CATARACT, UPPER EGYPT.

At the first cataract, the Nile flows over crystalline rocks consisting principally of quartz, felspar, and hornblende, combined in various proportions, and then appearing under the forms of syenite, greenstone, hornblende, and mica-schists, or else occurring in separate masses. In the bed of the river the surface of the harder portions of these rocks is beautifully polished. The whole district is traversed by dykes of greenstone, of which the prevailing direction is E. and W. The crystalline rocks forming the bed of the river are overlaid by a sandstone, sometimes coarse and gritty, and at other times fine-grained and compact. The prevailing color is light-yellow, but in places it is dark-purple and even black, owing to the presence of iron. As yet no organic remains have been discovered in it. This sandstone rests on the uneven surface of the syenite in slightly inclined strata, dipping N.N.E. It is nowhere altered at its junction with the syenite, nor is it anywhere penetrated by dykes. To the eastward of the first cataract is a wide valley, commencing opposite the Island of Philæ, and joining the Nile valley again about three miles below Assouan. Through this valley the Nile may have formerly flowed, as freshwater shells and deposits of Nile-mud are found at a considerable height above the present level of the river. To the westward of the first cataract, the crystalline rocks disappear below the sandstone, and the country is almost entirely covered with sand of a rich yellow color, composed of fine rounded grains of quartz.— J. C. Hawkshaw, *in Reader.*

ON THE ORIGIN OF PRAIRIES.

The origin of prairies has recently formed the subject of three papers in the "American Journal of Science," 1865, by Prof. Winchell, Mr. Lesquereux, and Prof. Dana, in the order mentioned. Prof. Winchell believes that the prairies are of lacustrine origin and of post-glacial date; that all seeds contained in these lacustrine deposits would perish, and that the vegetation which

afterward appeared "was more likely to be herbaceous than arboreal," because the seeds must have been brought from distant regions. Mr. Lesquereux considers that the prairies were formed by a process of natural reclamation from the borders of lakes, mouths, and banks of large rivers, and coasts of seas (fresh water and salt), and cites, in illustration, the cases of the Mississippi, Lake Michigan, etc. He thinks that the nature of the soil formed under these circumstances would be such as to favor only the growth of sedges and grasses; and he endeavors to show that his explanation will account for the existence of all known prairies and large flat tracts of land, including "the natural meadows of Holland," etc. Prof. Dana advances an explanation of a totally different nature, namely, that the absence of forests and presence of prairies are caused by the dryness of the climate, while conversely the presence of forests is caused by its moisture. Prof. Dana's facts are indisputable and generally received, for every one acknowledges the intimate relation of the moisture of the climate to the existence of forests; the only question is, which is the cause and which the effect. Experience has shown that the moisture of a climate may be increased by planting forests, and diminished by clearing them.—*Quarterly Journal of Science, April*, 1866.

ARTESIAN WELLS OF CHICAGO, ILLINOIS.

These wells, now discharging 1,250,000 gallons per day of the purest water, are located near the city limits, about three miles from the City Hall; they are 700 feet deep, and discharge an immense amount of clear cold water. In several respects these wells are anomalies; first, the water which rises to the surface stands at 57° Fahr., which is below the mean temperature of the locality, while in all other deep wells the temperature increases in proportion to the descent, so that no water is found at a greater depth at much less than 75°; and in the great wells at Charleston and in the basin at Paris the range is up to 85° and 90°. Then this water is free from the unpleasant and disagreeable mineral taints so common to Artesian wells. It is certified, under chemical analysis, to be the best article of drinking water in the world; and from the force and power with which it comes to the surface, it has a head of 125 feet above the level of Lake Michigan. There seems to be no doubt but that, by an enlargement of one of the wells to a diameter of 20 inches, a sufficient supply, estimated at 17,000,000 gallons per day, could be obtained to meet the demands of the city for years to come, and that this would flow into the reservoirs without the aid of expensive engines, steam-pumps, and fuel. Another curious feature in regard to these wells, and one which geologists have not yet explained, is found in the fact that they are located in no great valley or depression, like the basins of Paris and London, but are out on the level prairie, surrounded for hundreds of miles by country of a like character. This fact, taken in connection with the low temperature of the water and the great head of the fountains, seems to indicate that

it has a source far in the north or north-west, beyond Lake Superior, and beyond the Mississippi, perhaps away off in the Rocky Mountains. —*Mechanics' Magazine, Feb.*, 1866.

MINERAL RESEMBLING ALBERTITE, FROM COLORADO.

Prof. William Denton, when on an exploring trip west of the Rocky-Mountain Range, in July, 1865, found, near the junction of White and Green Rivers, a series of tertiary beds of brown sandstone, passing occasionally into conglomerate, and thin beds of bluish and cream-colored shale alternating with the sandstones.

These beds dip to the west at an angle of about 20°; and, cropping out from beneath them on the east are beds of petroleum shale, a thousand feet in thickness, varying in color from a light cream to inky blackness. One bed, ten feet in thickness, which he traced for six miles, is scarcely distinguishable from the best cannelite of New Brunswick. In the sandstone overlying the shales, he found a perpendicular vein of bitumen, resembling in lustre, fracture, and other physical characters, pure Albertite. This vein has a width of from two feet six inches, to three feet four inches; it lies between smooth walls of sandstone, and was traced for a distance of five miles in a nearly direct line, due west. Two more small veins were discovered parallel to the first, one south, and the other north, and each distant about a mile.

The sandstone has been eroded by water into ravines and cañons to a depth of from eight hundred to one thousand feet, and the principal vein can be traced from the top of the mountain to the bottoms of these cañons, retaining its width, but not apparently increasing it. In the sandstone he found fossil wood of deciduous trees, fragments of large bones, most of which were solid, and turtles, some of which were two feet in length, and perfect. The sandstone is probably of Miocene age.

In the petroleum shale, underlying the sandstones, are innumerable leaves of deciduous trees; among them he thought he recognized the willow, the maple, and the oak. Dipterous insects, resembling the musquito, and their larvæ, abounded; they are in a wonderful state of preservation.

The story that these beds tell seems to be this: A large freshwater or brackish lake existed, covering a considerable portion of western Colorado and eastern Utah. Streams carried down fine sediment and free petroleum, from numerous springs in the surrounding country, for ages; the petroleum increased in flow until the sediment of the lake became thoroughly charged with it, and the cannelite was the result. A change in the level of the country and the course of the streams is indicated by the overlying sandstones and conglomerates, nearly destitute of petroleum, and at least one thousand feet in thickness. During the time that this immense amount of sediment was being deposited, willows, maples, oaks, and many strange trees grew on the land, palæotheres and turtles swam in the waters, and clouds of insects sported over its surface. The bitumen seems to have flowed from

the shales as petroleum, after their upheaval, filling crevices perhaps formed by that upheaval, and to have hardened in time into its present form.

Analysis of this Bitumen by Aug. A. Hayes, M.D. — The physical characters of this mineral connect it with the variety of cannel coal called Albertite; a fact which gives great interest to the discovery, apart from economical considerations.

In chemical composition, relation to heat and solvents, it differs from Albertite remarkably, and falls within the class of true bitumens, of which it is an important member, well characterized.

When the cannel coal of New Brunswick was discovered and described, geologists and mineralogists were unwilling to class it with known coals of the cannel kind, on account of its general resemblance to some known bitumens. Jet, from the tertiary formation, seemed to be its nearest relative but so strong was the impression of its physical characters, that it received a distinctive name, by which it is now known. Meantime,observations have multiplied over a larger surface, and in this country two discoveries have been made which render the reception of a new fact less difficult.

1. The discovery, some seven years since, of the bitumen of Ritchie County, Va. This is a true bitumen, filling a chasm in the sandstones of the coal formation, without shales or clay, and the deposit is extensive above the surface, and continuous more than one hundred feet below it.

The physical characters of this bitumen do not differ from those of bituminous coal of the prismatic form. Geologists and mineralogists have carefully examined and pronounced it coal. In place, it is a bitumen, and all its chemical characters and composition fix it firmly in the class of bitumens.

Here we have a bitumen with the external characters of coal, so distinct as to place it among the more common coals on inspection.

2. Prof. Denton has made known a most valuable deposit of oil-producing bitumen, whose external characters are exactly those of the so-called Albertite, while the mineral in place fills a fracture in the rocks, without shales or clay. Either in its bed, or in the laboratory, it is a true bitumen, differing from Albertite as bitumens differ from coal.

These discoveries seem to diminish the apparent objections urged to receiving the Albertite as a cannel coal, in the way of presenting a coal on the one hand which is bitumen, and an Albertite on the other, which is also a bitumen. They show, too, the important aid which may be derived from chemical inquiries, connected with geological observations.

In physical characters, this mineral resembles the Albertite of New Brunswick. The same variety of fracture is observed, and hand specimens side by side hardly differ. Specific gravity varies from 1.055 to 1.075; electric by friction.

When heated, it loses 0.33 per cent. of moisture, and at 340° Fahr. begins to emit vapors of hydrocarbons, soon melts and intumesces. It expands about five times its volume in decomposing, and affords a porous brilliant coke.

It partially dissolves in the lighter hydrocarbons from coal and petroleum. In petroleum naphtha, of 39.67 per cent. of dark brown bitumen separated from residuary humus, one hundred parts afforded when distilled —

Moisture	0.33
Bitumens and Gas	77.67
Carbon as Coke	20.80
Ash	1.20
	100.00

— *Proc. of Boston Society of Natural History*, 1866.

FORMATION OF COAL FROM PETROLEUM.

One of the more generally accepted theories respecting the formation of petroleum, supposes that substance to be a product of the destructive distillation of coal by means of the earth's internal heat. There is being discussed just now, however, a theory which is the exact converse of this, — a theory, according to which, instead of petroleum being formed from coal, coal was formed from petroleum. It is well known that "all organic substances which are not themselves volatile, such as wood, flesh, and other vegetable and animal matters, yield, when subjected to the influence of heat below dull redness, tarry oils, having in all cases the general character of petroleum, and differing only according to the specific differences in the materials from which they may have been obtained;" and the new hypothesis supposes that the materials from which our coal-beds were formed were converted in the first instance into such "tarry oils," and that these oils, under the long-continued action of heat, gradually lost nearly all their oxygen and the chief part of their hydrogen, the residuum gradually becoming solid. The advocates of this theory point in support of it to the phenomena presented by the celebrated "Pitch Lake" of Trinidad. This lake covers an area of ninety-nine square miles, and is of very great depth. "The bitumen is solid and cold near the shores of the lake, and gradually increases in temperature and softness towards the centre, where it is boiling. The ascent to the lake from the sea, a distance of three-quarters of a mile, is covered with a hardened pitch, on which trees and vegetables flourish; and about Point la Braye the masses of pitch look like black rocks among the foliage." Mr. G. P. Wall describes the lake as yielding three kinds of asphaltum: "1. Asphaltum glance, which is hard and brittle, of an intensely black, brilliant lustre, and conchoidal fracture. 2. Ordinary asphaltum, of a brownish-black color, containing 20 to 35 per cent. of earthy admixture and a considerable proportion of water, and possessing the property of plasticity, which it gradually loses on long exposure to the sun and atmosphere. 3. Asphaltic oil, occurring associated and diluted with water, but appearing, when concentrated, as a dense black fluid with a powerful bituminous odor. If collected in an open vessel, the more volatile part of this oil evaporates after a few months, leaving a solid black substance,

of similar appearance and analogous properties to asphaltum glance." It is alleged that the theory of coal having been condensed from a liquid, in the same way as this "asphaltum glance," accounts better than any other for its purity, seeing that "all impure or foreign substances which did not decompose would most likely be of greater specific gravity than oil, and consequently sink to the bottom."

The high state of preservation in which plants frequently occur in our coal-beds, and the fact of trees being found erect in them, are easily accounted for upon this theory. Trees grow on the hardened pitch of the Trinidad lake, within a short distance of other pitch in a state of ebullition, and one can readily conceive of the hardened pitch, in any similar case, being softened by the eruption of the boiling pitch, and of the trees growing on it being thus ingulfed, or of the lake overflowing its banks and so submerging adjacent vegetation. The new theory also furnishes a simple explanation of the "exceeding minuteness of many coal-seams, which thin out into mere filaments over extensive areas of solid rock," and might well be due to an oily liquid having overflowed the rock when it was at the surface, and having then, in process of time, in part evaporated and in part solidified. The shape and dimensions of many other coal-seams are equally consistent with the idea of the seams in question being the solid residuum of what once were lakes of oil, and indeed the great majority of all the known coal-formations are basin-shaped, "with long and sloping sides dipping down to a common and profound centre;" a fact which certainly tells with great force in favor of the new hypothesis. On the whole, it must be admitted that the theory that the first step in the formation of coal was the production of "tarry oils," by the destructive distillation, at a comparatively low heat, of vegetable and perhaps animal matter, and that coal consists of the less volatile portions of these oils, solidified and hardened by heat and pressure, is not without plausibility, at least in respect of certain kinds and formations of coal. There are some coal-beds which present phenomena which could scarcely, so far as we can at present see, be accounted for on this theory; but further researches will doubtless throw additional light on the whole matter; and it is not necessary that we should suppose that all the coal that exists was formed precisely in the same way. — *Mechanics' Magazine.*

ORIGIN OF PETROLEUM.

In "Silliman's Journal," for July, 1866, is an article on "Petroleum and its Geological Relations," by Prof. E. B. Andrews, of Marietta, Ohio, from which the following are extracts: "Of the origin of petroleum there are different opinions. All agree, however, that it must ultimately be traced to vegetable or animal substances, the primary combinations of hydrogen and carbon being the product of vital force. It is the opinion of Dr. J. S. Newberry and others that petroleum in its present form is the product of a slow distillation of bituminous strata. From this theory Mr. T. S.

Hunt, of the Canada Survey, in the 'Geology of Canada,' p. 526, dissents, and quotes approvingly the views of Mr. Wall, who investigated the bitumens of Trinidad, and who writes that the bitumen 'has undergone a special mineralization, producing a bituminous matter instead of coal or lignite. This operation is not attributable to heat, nor of the nature of a distillation, but is due to chemical reactions at the ordinary temperature and under the normal conditions of climate.' It would appear to be Mr. Hunt's opinion that the bitumens, of which petroleum is the liquid form, are the product of chemical reactions changing the original organic materials directly into oil and kindred hydrocarbons. . . . There is no doubt that, at the original bituminization of organic matter, vast quantities of bitumen were formed. The greater portion of this was absorbed by the sediments which now constitute bituminous strata. For example, the black shales of the Ohio Devonian rocks are two hundred and fifty feet thick, and in them the bitumen is uniformly distributed throughout the whole mass. This distribution would imply that the bitumen was once in such a state of fluidity as to allow it to diffuse itself. . . . All the oil that I have ever seen, except very insignificant quantities in isolated cavities in fossiliferous limestones, has evidently strayed far from its place of origin. It is seldom, indeed, that we find any oil in juxtaposition with bituminous strata of any kind. It is more often found in fissures in sand-rocks, rocks in which no oil could ever have been generated; for whatever organic matter they might have contained was too much exposed to atmospheric oxygen to admit of the possibility of any bituminization. It is not only impossible that the oil could have originated in these sand rocks, or in the arenaceous shales which underlie them in western Pennsylvania, but it is most probable that the oil ascended from the still lower rocks, in the form of vapor, which condensed in the superior cavities. In other words, the oil which, according to the theory, was formed far below in the original bituminization of organic matter, must have undergone a process of distillation.

"In favor of the other theory, that petroleum, as now generally found, is the product of a distillation of bituminous shales, etc., as suggested by Dr. Newberry and others, the following arguments may be urged: 1. Oil may be artificially produced by distilling such shales and other bituminous materials. . . . 2. The phenomena of oil and gas exhibited in our oil fields greatly resemble those observed in the artificial distillation of oil from bituminous materials. . . . 3. It is believed that some petroleum has been actually produced in the earth by distillation. . . . 4. There is an abundance of oil-making material in the earth. . . . 5. A comparatively low temperature is believed to be adequate to set free the oil vapors. 6. By this theory there might be produced an almost indefinite quantity of petroleum, since bituminous strata are found widely distributed. . . . Finally, the agency which would volatilize the liquid bitumen, or petroleum formed by direct bituminization, and bring it up and distribute it through the present oil horizons, would certainly be adequate to distil the bituminous shales, etc., and bring up the oil to the same elevations.

"It may, however, be objected, that, if this theory of distillation be true, we ought somewhere to find the residuum, or debituminized shales, etc., remaining after the oil had been extracted. Such discovery could not justly be expected in surface rocks, because, according to the theory, the heat agency would at best be small, and could be scarcely felt near the surface. The question, then, would be reduced to this, viz., Do the borings in deep wells ever show that the deep bituminous strata have lost any of their original and normal quantity of bitumen?"

After presenting some facts bearing upon this point, he concludes as follows: "Such facts are not conclusive as to any positive loss of bitumen, but they are not without significance. Should I find many similar cases where strata, which are highly bituminous at their outcrop, are found to contain little bitumen at great depths, and, at the same time, the rocks above these buried strata containing in their fissures much oil, I think the inference, that the oil was derived from the bituminous shales, not unwarranted."

ACTION OF ICE IN FORMING LAKE BASINS.

Mr. Thomas Belt has published an essay, in which he maintains the action of glaciers in forming lake-basins. Supposing, he says, the existence of a depression in the pathway of a glacier which has reached such a depth that the ice simply fills it, what would happen? At the bottom and sides of the hollow, the ice would be slowly melted by the earth's heat, increasing with the depth of the basin. As the ice at the lower end of the basin melted, the whole mass would be pushed along by the thrust of the moving glacier above it. Into the crevice at the upper end would pour the water, coming down the bottom of the glacier, from above the basin, which would pass underneath and be forced out at the lower end, carrying with it the mud produced by the crushing down of the ice as it melted at the bottom, and by the grinding along its floor as it melted at the lower end of the basin. The water coming from above would assist in melting the ice, especially in summer; but its most important effect would be the scouring out of the bottom of the basin, so that an ever-clean face of rock would be presented to the huge natural tool operating upon it. Such an action would, in some measure, resemble that of a hollow drill, which has been prepared for boring holes in rock, through which a current of water is forced to carry off the ground stone. Mr. Belt accounts for the difference in depth of the lake-basins of Switzerland and Nova Scotia by stating that, in one case the ice-chisel operated on hard granites, and in the other, on soft, easily-worn materials. — *Transactions of the Nova Scotia Institute of Natural Science, Vol. II., No. 3.*

ORIGIN OF THE SALTS WHICH COMPOSE THE EARTH.

Mr. T. Sterry Hunt gives the following theory of the origin of salts, metallic veins, and other deposits, starting with the idea

that, at the commencement of the earth's history, the various substances in ignition reacted on each other: "The quartz, which is present in such a great proportion in many rocks, would decompose the carbonates and sulphates, and, aided by the presence of water, the chlorides both of the rocky strata and of the sea; while the organic matters and the fossil carbon would be burned by the atmospheric oxygen. From these reactions would result a fused mass of silicates of alumina, alkalies, lime, magnesia, iron-oxide, etc.; while all the carbon, sulphur, and chlorine, in the form of acid gases, mixed with watery vapor, nitrogen, and a probable excess of oxygen, would form an exceedingly dense atmosphere. When the cooling permitted condensation, an acid rain would fall upon the heated surface of the earth, decomposing the silicates, and giving rise to chlorides and sulphates of the various bases, while the separated silica might take the form of crystalline quartz. In the next stage of the process, the portions of the primitive crust not covered by the ocean would undergo a decomposition, under the influence of hot moist atmosphere charged with carbonic acid, and the felspathic silicates become converted into clay, with separation of the alkali. This, absorbing carbonic acid from the atmosphere, would find its way to the sea, where, having first precipitated from its highly-heated waters various metallic bases then held in solution, it would decompose the chloride of calcium, giving rise to chloride of sodium on the one hand, and to carbonate of lime on the other." — *Canadian Naturalist, Vol. II., note* 4.

GNEISS WITH IMPRESSION OF EQUISETUM.

In the Museum at Turin is a fragment of gneiss from an erratic block, apparently from the Valteline, from the crystalline rocks underlying the infra-liassic group of Sismonda, containing an impression of an Equisetum. Sismonda regards this fossil as proof of the metamorphic character of the fundamental gneiss of the Alps, and as affording a fact bearing on the age of the vegetable impressions accompanying the anthracite-bearing beds of the Western Alps.

ERUPTION OF ETNA.

M. Fouqué, in "Les Mondes," April 6, 1865, writes that at half-past 10 P. M., January 21, 1865, there was a severe earthquake, and immediately afterward the eruption commenced. It broke out at the north-east side of the mountain, 1,700 metres above the sea, and 500 from the foot of the old cone of Frumento; in two or three days the lava had flowed 6 kilometres, with a breadth of 3 to 4, and a thickness of 10 to 20. There are 7 craters. There are four kinds of fumaroles there; the dry, on the incandescent lava; the acid, where the temperature is above 400° C.; the alkaline, where the temperature is below this, but mostly above 100° C.; and the carbonic, in an old crater near by, where there is the ordinary temperature. There was a remark-

able absence of sulphur and its compounds, its odor not being perceptible, and paper containing acetate of lead not being blackened by the fumes. Muriate of ammonia was detected in the acid fumaroles, and, in small quantity, even in the dry, as well as the alkaline. The four lower craters detonated differently from the other three; the detonations of the latter were two or three per minute, resembling thunder, while those of the former were a continuous series, too rapid to be counted, like the blows of a hammer on an anvil.

VOLCANIC ERUPTION AT MAUNA LOA, HAWAII.

A jet of lava, of more stupendous proportions than any ever conceived of, is described by Mr. Coan in the Honolulu "Friend" of February, in his account of the eruption of Mauna Loa, on the Island of Hawaii, in 1865–1866.

"The eruption commenced near the summit of the mountain, and only five or six miles south-east of the eruption of 1843. For two days this summit crater sent down its burning floods along the north-eastern slope of the mountain; then suddenly the valve closed, and the great furnace apparently ceased blast. After thirty-six hours the fusia was seen bursting out of the eastern side of the mountain, about midway from the top of the base.

"It would seem that the summit lava had found a subterranean tunnel; for, half-way down the mountain, when coming to a weak point, or meeting with some obstruction, it burst up vertically, sending a column of incandescent fusia one thousand feet high into the air. This fire jet was about one hundred feet in diameter, and was sustained for twenty days and nights, varying in height from one hundred to a thousand feet. The disgorgement from the mountain-side was often with terrific explosions, which shook the hills, and with detonations which were heard for forty miles. This column of liquid fire was an object of surpassing brilliancy, of intense and awful grandeur. As the jet issued from the awful orifice, it was at white heat. As it ascended higher and higher, it reddened like fresh blood, deepening its color, until, in its descent, much of it assumed the color of clotted gore.

"In a few days it had raised a cone some three hundred feet high around the burning orifice, and as the showers of burning minerals fell in livid torrents upon the cone, it became one vast heap of glowing coals, flashing and quivering with restless action, and sending out the heat of ten thousand furnaces in full blast.

"The struggles in disgorging the fiery masses, the upward rush of the column, the force which raised it one thousand vertical feet, and the continuous falling back of thousands of tons of mineral fusia into the throat of the crater, and over a cone of glowing minerals, one mile in circumference, was a sight to inspire awe and terror; it was attended with explosive shocks which seemed to rend the mural ribs of the mountain. From this fountain a river of fire went rushing and leaping down the mountain with amazing velocity, filling up basins and ravines, dashing over preci-

pices and exploding rocks, until it reached the forests at the base of the mountain, where it burned its fiery way, consuming the jungle, evaporating the water of the streams and pools, cutting down the trees, and sending up clouds of smoke and steam and murky columns of fleecy wreaths to heaven.

"All Eastern Hawaii was a sheen of light, and our night was turned into day. So great was our illumination that one could read without a lamp, and labor and travelling and recreation might go on as in the daytime. Mariners at sea saw the light at two hundred miles distance.

"In the daytime the atmosphere for thousands of square miles would be filled with a murky haze, through which the sunbeams shed a pale and sickly light. Smoke, steam, gases, ashes, cinders floated in the air, sometimes spreading out like a fan, sometimes careering in swift currents upon the wind, or gyrating in ever-changing colors in fitful breezes. The point from which the fire-fountain issued is ten thousand feet above the level of the sea, thus making the igneous pillar a distinct object of observation along the whole eastern coast of Hawaii.

"During the eruption the writer made an excursion to the source. After three days of hard struggling in the jungle and over fields, ridges, and hills of bristling scoria, he arrived near sunset at the scene of action. All night long he stood as near to the glowing pillar as the vehement heat would allow, listening to the startling explosions and the awful roar of the molten column, as it rushed upward a thousand feet, and fell back in a fiery avalanche which made the mountain tremble. The fierce, red glare, the subterraneous mutterings, the rapid explosions of gases, the rushes and roar, the sudden and startling bursts, as of crashing thunder — all were awe-inspiring, and all combined to render the scene one of indescribable brilliancy and of terrible sublimity. The rivers of fire from the fountain flowed about thirty-five miles, and stopped within ten miles of Hilo. Had the mountain played ten days longer it would probably have reached the shore."

ASCENT OF MOUNT HOOD.

A correspondent of the "Springfield Republican" gives an account of the ascent of Mount Hood, Oregon, recently, by Prof. A. Wood, and a party of gentlemen. It would seem that Mount Hood is really a volcano, and that it is the highest mountain in the United States, 17,600 feet high. He says: —

"The summit area is of very limited dimensions — a crescent in shape, half a mile in length, and from three to fifty feet in width. It is a fearful place, as it is the imminent brow of a precipice on the north, sheer down not less than a vertical mile of bare columnar rock. This height is lifted so far above all other heights (except the four distant snow-clad peaks to the north, and Mount Jefferson on the south), that the country beneath seemed depressed to a uniform level, and the horizon retreated to a distance of more than two hundred miles, including nearly all Oregon and

Washington Territories. The sublimity and grandeur of that view I must leave to the imagination of the reader.

"A cañon of enormous depth plunges down along the south-east bank, and is filled in part by a glacier evidently in motion, and having below a very abrupt termination. Terminal and lateral moraines mark its course, and a torrent of water issues from beneath. While we delayed here, an avalanche of rocks, an immense mass, started by the wind, thundered down the left wall of this cañon several thousand feet, and its track was marked by a trail of white smoke. On the west side of the ancient crater, at the base of a vast craggy pinnacle of rocks (a portion of the ancient rim of the crater), is still an open abyss, whence issue constantly volumes of strongly sulphurous smoke. That there is also heat there, is evident from the immense depression of the snow about this place, — depressed not less than one thousand feet below the snows which fill to the brim other portions of the ancient crater."

MUD VOLCANOES.

Prof. Ansted communicated a paper to the Geological Society on the mud volcanoes and salt lakes of the Crimea, giving an account of his recent explorations of the seat of the great Russian campaign. He thinks that mud volcanoes are due to causes not different in their nature from those of ordinary volcanoes, though far less powerful in degree. He concludes that the facts, 1, That the volcanic axis is identical with the great elevation axis; 2, That the axis of the smallest and most recent action of mud volcanoes is, in like manner, parallel to the most important movements that have affected the surface of the globe; 3, That chemical changes and results, mineral waters, naphtha, and eruptions of various gases, are all connected very directly with similar lines of action; — are all sufficiently indicative of a general causation.

VOLCANIC ERUPTION IN THE BAY OF THERA (SANTORIN).

From Greece, intelligence has arrived that a new island began to rise above the level of the sea in the Bay of Thera (Santorin) on the 4th of February, 1866, and in five days attained the height of from one hundred and thirty to one hundred and fifty feet, with a length of upwards of three hundred and fifty feet, and a breadth of one hundred feet. It continues to increase, and consists of a rusty black metallic lava, very heavy, and resembling half-smelted scoria which has boiled up from a furnace. It contains many small whitish semi-transparent particles disseminated through the mass like quartz or felspar.

The island of Santorin, or Thera, is of a crescent shape, and is apparently part of the crater of an enormous volcano, eighteen miles in circumference. The islands of Therasia and Aspronisi were separated from Calliste, the Beautiful, as Santorin was then called, by an earthquake, described by Pliny. Three small islands, thrown up at different periods, are situated nearly at the centre of the crater, and it is to the south of one of these, Neo-

Kaimeni, that the new island has just made its appearance, which phenomenon has been fully described by the Athens correspondent of the "Times." It will probably form a junction with Neo-Kaimeni, which was raised in 1707 and the following years. The best account of the island of Santorin and the surrounding islets is perhaps that contributed by Lieut. Leycester to the twentieth volume of the "Journal of the Royal Geographical Society." Those of our readers who care to know more of this interesting volcanic group, in which, as Humboldt says, we may trace the perpetual efforts of nature to form a volcano in the middle of a crater of elevation, will do well to refer to it. The paper is accompanied by an Admiralty chart, on which the soundings are laid down.

The new island was named "Aphroessa" by the Greek commissioners. It was stated to be one hundred yards long by fifty wide, and to be daily increasing in size. Volcanic eruptions had taken place in two localities, one in the new island, and the other in what was called Mineral Creek, which is about two-fifths of a mile distant, and which had been completely filled up with lava. Considerable concussions were experienced at Patras and other parts of Greece, which were by some attributed to an earthquake, and by others to volcanic explosions; but, with these exceptions, no earthquake had attended the eruptions or the formation of the island.

The results of a long letter by M. Fouqué are thus summed up: 1. A fissure in the soil lying 20° N.E. exists in the southern part of Neo-Kaimeni; Georges, Aphroessa, and Reka, being the three principal points. At their level there issue from this fissure currents of lava, which diverge from every side towards the south and north; that is, very nearly at right angles to the direction of the fissure. 2. The dimensions of the three centres of eruption become larger every day, much more owing to the development of these currents than to the upheaval of the soil. 3. There has been a considerable upheaval of the floor of the sea between Reka and the southern point of the Paleo-Kaimeni. 4. There has also been very lately a very marked upheaval of that portion of Neo-Kaimeni comprised between Georges and Aphroessa. 5. The sinking of the south extremity of Neo-Kaimeni, which seemed to have come to an end, has again commenced. 6. Georges, Aphroessa, and Reka are completely reunited with Neo-Kaimeni.

Since the eruptions at Santorin earthquakes have become much less violent in the surrounding country, and the fears of the inhabitants have been unnecessarily great. A new fissure has been opened between Georges Island and Aphroessa; and lava and torrents of steam have issued from this vent, as well as much gas. The non-existence of a crater was considered by M. Fouqué to be due to the small quantity of ejected matter and the feebleness of the eruption. M. St. Claire Deville has shown that there exists a certain relation between the degree of intensity of a volcano in action and the nature of the volatile elements ejected; and M. Fouqué has been enabled to establish the truth of this law. Thus, in an eruption of maximum intensity, the predominant volatile

product is chloride of sodium, accompanied by the salts of soda and potash; an eruption of the second order gives hydrochloric acid and chloride of iron; in the third degree, sulphuric acid and salts of ammonia; and, in the fourth or most feeble phase, steam only, with carbonic acid and combustible gases. The eruption at Neo-Kaimeni has never exceeded the third degree of intensity; and, when it excited the greatest alarm, it gave off only sulphuric acid, steam, and combustible gases.

The active volcano now forming part of the Neo-Kaimeni Island continues to increase in size by the addition of volcanic matter ejected from the crater, and the rate of increase of the new island situated to the south-west, near St. George's Bay, is considerably less than at first. The new island contains the crater of a second volcano, thirty feet in height, with a circular base of three hundred yards; and, judging from the soundings obtained at Paleo-Kaimeni and St. George's Bay, it is probable that the island will eventually fill up the bay.

THE STRUCTURE AND AFFINITIES OF EOZOÖN CANADENSE.

This object has been the cause of much discussion among geologists, some maintaining it to be an inorganic substance assuming an animal-like form, while others have decided that it is a fossil. Messrs. King and Rowney, of Queen's College, Galway, in January, 1866, maintained, before the Geological Society, that it is the result of what they term mineral segregation. The following had been communicated to the "Reader" as early as June 3, 1865: —

"For several weeks past we have been engaged in investigating the microscopic structure of the serpentine of Connemara, in comparison with that of a similar rock occurring in Canada, which has attracted so much attention of late. For a considerable portion of the time, we entertained the opinion, in common with Sir William Logan, Doctors Dawson, Sterry Hunt, Carpenter, and Professor Rupert Jones, that the Canadian serpentine is of organic origin, the result of the growth of an extinct foraminifer, called Eozoön Canadense. It was also our belief for a while that the Connemara rock had originated from a similar organism. Gradually of late, however, we have been reluctantly compelled to change our opinion.

"It is now our conviction that all the parts, in serpentine, which have been taken for the skeleton-structures of a foraminifer, are nothing more than the effect of crystallization and segregation."

Dr. Carpenter followed with a paper showing that it is a foraminiferous fossil. In this paper Dr. Carpenter stated that a recent siliceous cast of Amphistegina from the Australian coast exhibited a perfect representation of the "asbestiform layer," which had previously led him to infer the nummuline affinities of that ancient foraminifer, — a determination which has since been confirmed by Dr. Dawson. This "asbestiform layer" was shown to exhibit in Eozoön a series of remarkable variations, which can be closely paralleled by those which exist in the course of the tubuli in the shells of existing nummuline foraminifera, and to be associated

with a structure exactly similar to the lacunar spaces intervening between the outside of the proper walls of the chambers and the intermediate skeleton, by which they become overgrown. He stated that, even if the remarkable dendritic passages hollowed out in the calcareous layers, and the arrangements of the minerals in the Eozoic limestone, could be accounted for by inorganic agencies, there still remains the nummuline structure of the chamber walls, to which no parallel can be shown in any undoubted mineral product.—*Popular Science Review, April,* 1866.

DRIFT IN BRAZIL.

According to Prof. Agassiz, as reported by his son in "Silliman's Journal," for Nov., 1865, at Tijuca, a cluster of hills about eighteen hundred feet high, and about seven or eight miles from Rio, there is a drift hill with innumerable erratic boulders, as characteristic as any ever seen in New England. He had before seen unmistakable traces of drift in the Province of Rio and in Minas Geraes; but there was everywhere connected with the drift itself such an amount of decomposed rocks of various kinds, that it would have been difficult to satisfy any one not familiar with drift, that there is here an equivalent of the Northern drift. There is found at Tijuca the most palpable superposition of drift and of decomposed rocks, with a distinct line of demarcation between the two.

This locality afforded an opportunity of contrasting the decomposed rocks, which form a characteristic feature of the whole country, with the superincumbent drift, so as to be able hereafter to distinguish both, whether found in contact or separately. These decomposed rocks are quite a new feature in the structure of the surface of the country. Granite, gneiss, mica slate, clay slate, in fact all the various kinds of rocks usually found in old metamorphic formations, are reduced to the condition of a soft paste, exhibiting all the mineralogical elements of the rocks as they may have been before they were decomposed, but now completely disintegrated, and resting side by side, as if they had been accumulated artificially. Through this loose mass there were here and there larger or smaller veins of quartz rock, or of granite or other rocks, equally disintegrated; but they retain the arrangement of their materials, showing them to be disintegrated veins in large disintegrated masses of rocks. The whole passes unmistakably to rocks of the same kind, in which the decomposition or disintegration is only partial, or no trace of it is visible; and the whole mass exhibits, then, the appearance of a set of ordinary metamorphic rocks. It is plain that such masses forming everywhere the surface of the country must be a great obstacle to the study of erratic phenomena; and it is not wonderful that those who seem familiar with the country should entertain the idea that the surface rocks are everywhere decomposed, and that there is no erratic formation or drift here. But, upon close examination, it is easy to see that, while the decomposed rocks consist of the small particles of the primitive rocks, which they represent, with their veins and all other charac-

teristic features, there is not a trace of larger or smaller boulders in them; while the superincumbent drift, consisting of similar parts, does not show the slightest sign of the indistinct stratification characteristic of the decomposed metamorphic rocks below it, nor any of the decomposed veins, but is full of various kinds of boulders of different dimensions. The boulders have not yet been traced to their origin; the majority consist of a kind of greenstone, composed of nearly equal amounts of a greenish black hornblende and felspar. This greenstone is said by mining engineers to be found in the Entre Rios on the Parahiba, where iron mines are worked in a rock like these boulders. Thus far, evidence has been furnished of the action of glaciers only in the extensive accumulations of drift similar in its characteristics to Northern drift; but no trace has been found of glacial action, properly speaking, such as polished surfaces, scratches, and furrows.

The decomposition of the surface rocks to the extent to which it takes place here is very remarkable, and points to a geological agency thus far not fully discussed in our geological theories. It is obvious that the warm rains, falling upon the heated soil, must have a very powerful action in accelerating the decomposition of rocks; it is like torrents of hot water falling for ages in succession upon hot stones; and, instead of wondering at the amount of decomposed rocks, we should rather wonder that there are any rocks left in their primitive condition.

GEOLOGY OF THE VALLEY OF THE AMAZON.

The Basin of the Amazon. — Prof. Agassiz, in his lectures before the Lowell Institute, in Boston, in October and November, 1866, made the following statements in regard to the geology of the valley of the river Amazon, from his personal observation. The formation of this basin is the same for a distance of three thousand miles. It consists: 1. Of a horizontal bed of white thinly-laminated clay, on which the river flows, and exposed at low water, this water-level showing that the basin has not changed its relative position with the ocean since its formation. 2. Over this is a ferruginous sandstone, in horizontal stratified layers, forty to eighty feet thick, later than the old red sandstone, and even than the trias, to which it had been referred respectively by Humboldt and Martius. 3. Over this, on the slopes near the water, and on the top of the flat mountains seen from time to time, is an ochre-colored, very rich loam, constituting the fertile lands of the valley. These flat-topped hills, once a continuous mountain range, have assumed their shape of rounded hills by denudation from the weather, heavy rains, etc., — the only instance known of mountains made by simple denudation, as these are generally the result of upheaval or subsidence. These strata must have been deposited perfectly horizontal, in a walled basin; in this valley we have the Andes on the west, the mountains of Bolivia and the table-land of Brazil on the south, the high land of Guiana at the north; but nothing on the east, toward the ocean.

Erosion of the Coast of Brazil. — He said that there had taken place on the coast of Brazil the most extraordinary encroachments in the annals of geology, that there had also been great displacement in the whole Amazonian valley, and that all these changes had occurred within a comparatively recent geological period. It had become an axiom in geology that the highest mountains were the most recent; and, therefore, the table lands of Guiana and high lands of Brazil are older than the Andes. It had been ascertained, by scientific explorations fifteen years ago, that the slopes of the mountains dipping toward the north contain deposits belonging to the transition period. The recent upheaval of the Andes showed that the trough now formed by them was once open to the Pacific. This valley, in its formation, had many of the characteristics of the valley of the Mississippi, which was formed, first, by the upheaval of the Laurentian hills to the north, trending east and west; next, the upheaval of the Alleghanies, trending north and south, and leaving the plain of the Ohio open to the Pacific; and, last, the upheaval of the Rocky Mountains. It became therefore an interesting question, how far the Mississippi trough was lined with cretaceous deposits. By the discovery of fossil fishes in the Ceara region, its age had been determined as belonging to the cretaceous period. He was free to admit that the basin had its present outline since the cretaceous period, and that whatever was now found within that trough was younger than the cretaceous beds. It had since been filled with deposits before described, and was now losing ground by the encroachments of the sea.

He gave the results of his examination of the coasts of Para River, and other localities farther south, proving, by the existence of fragments of peat and stumps of trees on the coasts below highwater mark, that 'solid land once existed where now the sea flows. There was evidence that there was a time when the bay of Narajo, now sixty miles wide, did not exist. Great changes had taken place even within three years. Encroachment was going on everywhere at the mouth of the Amazon, by the conflict of the tidal currents with the waves of the sea. There could be no doubt that all the islands on the coast owed their existence to this cause, and that the coast was once a continuous line. If so, the question arose, Through what channel did the Amazon then discharge its waters? He answered this question by giving his opinion that the river formerly found its way through what is now the island of Narajo.

In considering the question how far these encroachments had gone, Professor Agassiz stated his belief that the coast formerly extended three hundred miles beyond its present boundaries, from the promontories of Ceara to Eastern Guiana. It was also probable that some of the streams, now flowing into the ocean south of the Amazon, were tributaries of that river before the coast was encroached upon by the sea; and he was inclined to believe that the coast in the vicinity of the Orinoco had been similarly denuded, and that the continent was once joined with the West India Islands. How far the Gulf of Mexico owed its existence to the same origin was a question for geologists to decide.

He commented at some length upon the difference in the appearance of the glacial materials in the valley of the Amazon and in more Southern parts of Brazil. In the valley, he observed, these materials were regularly stratified, while in other localities they were blended. He had drawn from the first-mentioned fact the conclusion, that the valley was once barred to the sea and formed into a lake by the accumulation of a moraine; and, upon investigation and inquiry, he had found evidence to sustain this theory, in the existence of extensive remains of the moraine.

On the Drift and Glaciers of the Amazon Valley.—Taking the regions about the provinces of Ceara and Rio for illustration, he said the whole country within the former province is flat; but from this plain rise hills of considerable height, some reaching as high as three thousand feet. These mountain masses are composed of metamorphic rock, and present a remarkable degree of disintegraion. This disintegration can be seen, in the neighborhood of Rio, penetrating at least three hundred feet, even where the rock is continuous from the surface downward. The solid rock is not only affected by this disintegration, but the loose materials show it, so that it is difficult to recognize their primitive condition, and to trace their relation to the original material on which they rest. He was satisfied that large masses of what we call drift rest on the tropical solid rocks, as well as upon the rocks in the northern regions; and that these are erratic is plain from the fact that they are not of the same mineral character as the rocks underneath them. In this connection he stated that it was a curious fact, that wherever rocks have been moulded by the power of ice they present a rounded, dome-like shape. This condition of these rocks and loose material is proof of the former existence of glaciers.

But we have more direct evidence of the existence, at one time, of local glaciers. In the vicinity of Mangouva he had been struck with the character of the loose material, and upon examination had found that on both sides the valley, on the steep slope of the mountains, there were large accumulations of boulders. These boulders were firmly fixed on the slopes, but none were at the bottom of the mountains. Inquiring of the inhabitants of this region concerning these boulders, he had learned that they existed nowhere in the depressions, but were suspended along the valley on the sides of the mountains. He had moreover found this to be the case throughout the chain. Now, if these had been brought by water they would have slid to the bottom, and could not have fastened themselves upon the sides of the mountains. He said that in his mind these were proofs, beyond the possibility of a doubt, of the existence of local glaciers descending from the summit of the hills to the plains, posterior to the great extension of ice over the continent.

Again alluding to these boulders, he said that he had found these perch rocks, on the summit of the mountains, of an entirely different character from the rocks on which they rest. And these must have been brought by an agency none other than ice. If they had been brought by flood, they would have been thrown over the side of the hills. But if the boulders had been carried on the back

of a sheet of ice, they would have been placed as they are; for when in course of time the ice began to wane, it would lessen in thickness nearest the prominent points underneath, and would gradually melt away from them, and drop the boulders on their summit, and in time leave them firmly stationed, away from its action. He concluded, then, from these facts that, at one time, in that now tropical region, there was an immense sheet of ice moving over the valleys and mountain peaks, and that gradually it had melted away, leaving its marks and tracks behind.

On the supposition that the valley of the Amazon was once filled by an immense glacier, the horizontality of the strata would be well explained. At first the ice melted slowly, with still water underneath, with a deposit of the finest materials; as the ice melted more rapidly, the under-current became stronger, with a more disturbed deposition of coarser materials. A moraine was also found on the southern side. These deposits could not have been made by the sea, nor in a large lake, as they contain no marine nor fresh-water fossils.

From the facts developed, the conclusion had been reached, that there was a time when not only the northern and southern hemispheres, and the temperate zones, were covered with fields of ice, but when the phenomena extended over the tropical regions. It might be said that one proof of the phenomena was wanting, for nowhere had he been able to trace the polished rocks. But then, nowhere had he seen rocks which had not been more or less decomposed, owing to the action of moisture and heat; so he could not say that he had in any case seen the natural surface of the rocks, and therefore it could not be wondered at that the evidence of attrition was wanting. The other collateral evidence is full, and as extensive as in the northern and more temperate regions.

BIOLOGY;

OR, PHYSIOLOGY, ZOÖLOGY, AND BOTANY.

PROGRESS OF PHYSIOLOGY.

Prof. Huxley delivered an address to the "Section of Biology" of the British Association, in 1866, from which we extract the following: "The microscope has lately been to physiology much what the steam-engine has been to manufacture and transit. It has opened up new regions for observation, and given an entirely new direction to our thoughts. The structure of the several tissues and organs has probably been made out as far as the present means permit, and we are occupied now in investigating their mode of formation and connection with each other. There seems much reason to think that they are more closely related, more continuous, than we have been in the habit of regarding them." He goes on to speak of the probable continuity of the nerve fibres and nerve vesicles — of the other parts of the nerves with the tissues among which they ramify — of the areolar tissues with serous, fibrous, and mucous membranes, and with the structure of the various organs, and with blood vessels. "We are thus reminded of the fact that, in their embryonic period, the several structures, or the potential rudiments of them, were all blended in a homogeneous germinal mass; and we learn that, though they have become differentiated, they have not become separated, but retain, in their own mode of connection, the traces of their common parentage and of their early continuity. Such a blending of ultimate tissue, as a remnant of embryonic condition, assists us to explain many things, such as the transfer of impressions and what we call sympathy.

"We perhaps scarcely realize and appreciate the bearings of the fact, that all the various tissues are formed from a primitive homogeneous and continuous plexus, by the formation and separation from one another of 'portions,' 'centres," 'masses,' 'cells,' or whatever we please to call them, and their development into structure. Attention has been directed almost exclusively to the formation and development of these masses, and too little to their separation; though the latter is a process little, if at all, less important than the former, and must be effected by something analogous to what we call abruption. Indeed, the work of abruption, or hollowing out, during the embryonic state, is little less active than that of secretion or building up. We are familiar with its work in the formation of the areolar tissues and cavities of bone, in the removal of the parts of the iris and eyelids that do not become developed into permanent structure; but we are not perhaps sufficiently impressed with the fact that the various cavi-

ties, canals, and spaces, in the interior of the body are due to the same progress, and that the failure or arrest of it may be the cause of many of the so-called adhesions of seams and other surfaces, of the imperforate condition of canals, and the union of parts that should be free."

"It is quite clear that what we call 'Chemistry,' with its attendants, heat and electricity, plays a most important part in the animal machine; and, probably, more information as to the nature of the organic processes is to be expected from their chemical study than in any other way. We have found out that there is a very close relation between a complete atomic formula and the vital processes, the amount of chemical tension which is expressed by the former being commensurate with the character of the latter, and the amount of chemical change which takes place in the textures being commensurate with the activity of the vital processes. There seems good reason to believe that a muscular fibre is the container of a given amount of chemical force compressed by the medium of a high chemical formula, and existing, therefore, in a high state of tension; that during its contraction the compressed force is set free by the decomposition of its structure — that is, by the resolution of its component elements, chiefly by a process of oxidation, to a lower formula or a state of lower tension, at the same time that heat is evolved and electrical changes take place; though the latter are not yet distinctly defined. It is impossible, therefore, to avoid the application here of the doctrine of contractile force, which is being so clearly worked out in the organic world, and which seems to be the greatest advance that has for some time been made in our knowledge of the laws of matter. We can scarcely doubt that the chemical force which is set free during the decomposition attendant upon muscular action is the equivalent of the contractile force that is evinced, and of the heat that is evolved. In other words, a muscle may be regarded as the medium by which force is accumulated, rendered latent, or condensed in a condition of high chemical tension, and is, from time to time, as occasion may require, set free and converted into muscular or contractile force and heat."

Change from Life to Death. — In relation to the transition from life to death, a change which takes place under ordinary circumstances in the most delicate, insensible manner, — so that it is impossible to say when and how life ends and death begins, — he referred to the mode in which the parts of the ultimate tissue of the body become changed and cease to exist. Even in the instance of the cuticle, a structure comparatively under the eye as we watch the transition of the spherical deeper components to the flattened forms of the superficial strata, and the disintegration of the latter, we are at a loss to decide where living force ends. Clearly, it is not by an abrupt disintegration or solution, but by some slow insensible process, which savors rather of atomic change than of destruction. "Then one is inclined to ask, if the passage from the living to the unliving condition be of this insidious, inappreciable nature, may there not be a converse of a like kind, an insensible origination of, or conversion into life

and life's forms, going on somewhere in the far recesses of Nature's womb?"

THE BRAIN OF THE IMPLACENTAL MAMMALIA.

In a paper published in the "Proceedings of the Royal Society," by Mr. W. H. Flower, "On the Commissures of the Cerebral Hemispheres of the Marsupialia and Monotremata," is given the progress of cerebral anatomy, arising from the controversies of the last few years. It also demonstrates that all those animals which agree in the physiological character of suckling their young, and are separated thereby from every other creature, also agree in possessing the remarkable transverse band of fibres which connects the two hemispheres of the brain, and is called the corpus callosum, while neither bird, reptile, amphibia, nor fish, have hitherto disclosed a trace of that structure.

Thus the progress of cerebral anatomy, while it has destroyed the distinctions feigned to exist between man and the speechless higher mammals, has also annihilated the resemblances imagined to obtain between the lowest mammals and the ovipara.

At the outset, a confirmation is afforded of the important fact, first observed by Prof. Owen, that the brains of animals of the orders marsupialia and monotremata present certain special and peculiar characters, by which they may be at once distinguished from those of other mammals. The appearance of either a transverse or longitudinal section would leave no doubt whatever as to which group the brain belonged. In the differentiating characters to be enumerated, some members of the higher section present an approximation to the lower; but, as far as is known at present, there is still a wide interval between them, without any connecting link.

The differences are manifold, but all have a certain relation to, and even a partial dependence on, each other. They may be enumerated under the following heads:—

1. The peculiar arrangement of the folding of the inner wall of the cerebral hemisphere. A deep fissure, with corresponding projection within, is continued forwards from the hippocampal fissure, almost the whole length of the inner wall.

2. The altered relation (consequent upon this disposition of the inner wall) and the very small development of the upper transverse commissural fibres (corpus callosum).

3. The immense increase in amount, and probably in function, of the inferior set of transverse commissural fibres (anterior commissure).

But is not the main part of the "corpus callosum" of the placental mammals also represented by the upper and the anterior part of the transverse band which passes between the hemispheres of the marsupial brain, and radiates out in a delicate lamina above the anterior part of the lateral ventricle? The most important and, indeed, crucial test, in determining this question, is, its position in regard to the septum ventriculorum, and especially the precommissural fibres of the fornix. Without any doubt, in all

marsupial and monotreme animals examined (sufficient to enable us to affirm without much hesitation that the character is universal), it lies above them, as distinctly seen in the transverse sections. This is precisely the same relationship which obtains in man and all other mammalia, and this is one of the chief points in which not only the interpretation of facts, but the observation of them recorded in the present paper, differs from that of Prof. Owen.

The defective proportions of the part representing the great transverse commissure of the placental mammals, which appear to result from or to be related to the peculiar confirmation of the wall of the hemisphere, must not lead to the inference that the great medullary masses of the two halves of the cerebrum are by any means "disconnected." The want of the upper fibres is compensated for in a remarkable manner by the immense size of the anterior commissure, the fibres of which are seen radiating into all parts of the interior of the hemisphere. There can be little doubt that the development of this commissure is, in a certain measure, complementary to that of the corpus callosum. This is, moreover, a special characteristic of the lowest group of the mammalia, most remarkable because it is entirely lost in the next step of descent in the vertebrated classes.

After a description of the brain of a bird, the conclusion is arrived at, that, great as is the difference between the placental and implacental mammal, in the nature and extent of the connection between the two lateral hemispheres of the cerebrum, it is not to be compared with that which obtains between the latter and the oviparous vertebrate.

SOURCES OF THE FAT OF THE ANIMAL BODY, BY J. B. LAWES AND DR. J. H. GILBERT.

In 1842, Baron Liebig had concluded that the fat of Herbivora must be derived in great part from carbo-hydrates of their food, but might also be produced from nitrogenous compounds. Dumas and Boussingault had at first opposed this view; but subsequently the experiments of Dumas and Milne-Edwards with bees, of Persoy with geese, of Boussingault with pigs and ducks, and of the authors with pigs, had been held to be quite confirmatory of Liebig's view, at any rate, as far as the carbo-hydrates were concerned. But at the Bath meeting of the British Association, in 1864, Dr. Haydon expressed doubt on the point; and at the Congress of Agricultural Chemists, held at Munich last year, Prof. Voit, from the results of experiments with dogs fed on flesh, maintained that fat must have been produced from the nitrogenous constituents of the food, and that these were probably the chief, if not the only, source of the fat of the Herbivora. Baron Liebig disputed this conclusion; and his son, Hermann V. Liebig, has since sought to show its fallacy by reference to cows. The authors agreed with the conclusions of these latter authorities, but pointed out the inadequacy of the data relied upon by Hermann V. Liebig. They showed that, owing to the much less proportion of alimentary organs and contents, the higher charac-

ters of the food, the much larger amount of fat produced, both in relation to a given weight of animal within a given time and to the amount of food consumed, the much less proportion of the solid matter of the food that passed off in the solid and liquid excretions, and finally the larger proportion of fat in the increase, results obtained with pigs must be much more conclusive than those with either cows, oxen, or sheep. Numerous tables were exhibited, showing the results which had been obtained by the authors in experiments with pigs, from which the following conclusions were drawn: 1. That certainly a large proportion of the fat of the Herbivora, fattened for human food, must be derived from other substances than fat in the food. 2. That when fed on the most appropriate fattening food, much of the stored up fat must be produced from the carbo-hydrates. 3. That the nitrogenous constituents may also serve as a source of fat, more especially in defect of a liberal supply of the non-nitrogenous ones.

VELOCITY OF NERVOUS IMPRESSIONS.

Mr. W. F. Barrett communicates to the "Intellectual Observer," for June, 1866, a paper "On the Velocity of Nervous Impressions," from which the following are extracts: —

What, then, is the result of the investigations of Helmholtz on the velocity of the nerve force? It is one which, at first sight, is most astonishing; for the rate of propagation, compared with other forces, is extremely slow. The velocity of light is about 190,000 miles a second, and of electricity even more; but the velocity of the nerve force is only ninety feet a second, one-twentieth of the velocity of a cannon ball, about one-thirteenth of the velocity of sound in air, and about equal to the speed of an express train. No sensible difference was found between the velocity in the nerves of a man, and in those of a frog and other animals. In a creature so long as the whale, the rate of nervous transmission becomes very perceptible when the extremities have to be moved. The fact of a harpoon having been thrust into the tail of a good-sized whale would not be announced in the brain of the creature till a second after it had entered; and, as it would take a little more than another second before the command to move its tail would reach the appropriate muscles, a boat's crew might be far away before the animal they had pierced began to lash the sea. The nervous force travels more slowly when the nerves are submitted to a low temperature than when they are influenced by a high one. Besides the time required for the transmission of a stimulus through the nerves, the mind takes a certain period to form a conception, and then to prompt the limbs to act accordingly. This time, measured by a similar method, has been found to be about one-tenth of a second. The passage of a rifle-bullet through the brain would not occupy more than one-thousandth of a second; a stroke of lightning would pass through the body in much less time; and thus a person killed by either of these means would die without consciousness having time to be produced. The placid aspect of those who have thus died goes to prove that no pain was felt prior to the insensibility which followed the act.

LIMBS OF MAMMALIA.

Dr. Burt G. Wilder, in the "Memoirs of the Boston Society of Natural History," has brought prominently to view the remarkable relations existing between the anterior and posterior regions or poles of the vertebrate body, both as exhibited in the structure of the bones and muscles of the limbs, and the more general relations found in the body itself and the internal organs. The principle of antero-posterior symmetry or "longitudinality" seems to be characteristic of vertebrates, and has not been observed among other animals. According to this law, the anterior and posterior poles of the vertebrate body have organs and parts that are homologous and morphologically identical, although teleologically very different, while the corresponding parts on opposite sides are both morphologically and teleologically repetitions of each other. The body is divided into four regions, the thorax and head corresponding to the abdomen and pelvis. Some of the corresponding parts are as follows: "In the anterior region, enumerating from above, that is from the vertebral column downward, the nose or anterior nares, the upper lip, the mouth, the tongue, and the chin; posteriorly, the anal opening, the perinæum, the vaginal opening, the penis or clitoris, and the pubes." There are two principal diverticula of the alimentary canal, the lungs and the urinary bladder; the former open forward and the latter backward, and their outlets are between the pharynx or mouth and the tongue anteriorly, and the vaginal opening and the clitoris posteriorly. "The thyroid gland is in relation with the larynx much as the prostate gland is with the neck of the bladder." The heart is considered only a more or less complicated enlargement and convolution of the great arterial trunk. The anterior limbs are shown to be appendages of the basal segment of the skull, thrown backward by growth in the higher vertebrates, but occupying their morphological position in fishes and some young animals.

ORIGIN AND DEVELOPMENT OF ANIMAL LIFE.

Prof. H. J. Clark, in his work entitled "Mind in Nature," has fully discussed the various modes of reproduction, and increase among animals, the origin and early condition of ovarian eggs, and the changes they ungergo as development proceeds. The egg, considered as the lowest condition of animal life, is shown to consist at first of a mere spherical aggregation of albuminous and oily matters, like a simple cell, but with a bipolar character; *i. e.*, the albumen concentrates at one side of the spherical mass, and the more oily portion of the yolk on the opposite side. While the eggs of infusoria never attain a more complicated structure than this, in those of higher animals a further change takes place, resulting in the formation of the so-called germinal vesicle and germinal dot, which is to be considered only a continuation of the process commencing with the imperfect separation of the albumen from the oily portion in the lowest form of the egg, the difference being only in degree, and not in kind.

The egg is regarded as an animal from the first, but comparable only to the lowest forms of infusorial life. The continued development of the egg, or embryo, is shown to depend more or less upon secondary causes, — most so in the lowest animals, — and in this respect a comparison is made with those germ-like forms supposed to originate and develop wholly through secondary causes.

He adopts the four grand divisions of Cuvier, with modifications; and, with many others, believes that the Protozoa constitute a fifth division, as distinct from the others as those are among themselves; but he regards them as merging gradually into each other, as clouds that touch and mingle somewhat at their borders. The bipolar relations in the organization of all animals, and the bilaterality which is equally a fundamental feature of all, are illustrated; and it is shown that this is as characteristic of Radiata as of the higher groups; and it is claimed that the more or less radiated appearance is subordinate to bilaterality. The characteristic feature of Protozoa is stated to be spirality or obliquity, superimposed upon bilaterality. The Radiata are said to have "a type of organization in which the various organs repeat themselves, more or less, between the back and the abdominal midline of the body; that is to say, they are laterally repetitive on each side of an imaginary plane which divides the body exactly into right and left halves." The Mollusca are compared in a similar way to the other groups, thus: "The Zoöphytes are from back to front, dorso-ventrally, polymerous; the Articulata are from tail to head, uro-cephally, polymerous; and the Mollusca are monomerous." By detailed comparisons, it is shown that there are no actual transitions from one of the five great divisions to another; and that each has a distinct and characteristic mode of development and growth. — *Amer. Jour. of Science, May*, 1866.

SPONTANEOUS GENERATION.

A contest has been long going on between French savants on the question of spontaneous generation, some of the points of which have been alluded to in the "Annual of Scientific Discovery," for 1865, page 330, — those on the one side maintaining the questionable doctrine of spontaneous generation, whilst the champions on the other side hold that, under existing conditions, no organism comes into being without the previous existence of some other organism.

The French Academy appointed a Commission to endeavor to arrive at some settlement of the question, either by establishing heterogenesis (as the old doctrine is now called by its advocates) on the footing of an acknowledged fact, or finally consigning it to the grave of exploded theories. From an elaborate report, communicated in 1865, by M. Balard, to the French Academy, on the proceedings of this Commission, it would appear that, owing to certain difficulties raised by the partisans of heterogenesis, this desirable consummation has not been attained, at least, so far as they are concerned; although the experiments made in support

of the opposite opinion, under the inspection of the Commission, will abundantly suffice to satisfy most unprejudiced minds. But, as M. Balard observes in his report, "as nothing is so abundant as vague and inexact observations, conclusions deduced, at least apparently, from direct experiments, have never been wanting to support this doctrine of spontaneous generation."

On the 22d of June, M. Pasteur commenced his series of experiments, in presence of the Commission and of his antagonists, MM. Pouchet, Joly, and Musset. He first exhibited to the meeting three glass flasks, filled with air collected on the Montanvert in 1860, and showed that, even after the lapse of four years, the solution of yeast contained in them had undergone no alteration, and was perfectly transparent. The analysis of the air of one of these flasks showed that it contained no carbonic acid, and that the normal quantity of oxygen (21 per cent.) was still present in it. Another flask was broken at the neck in such a manner that its orifice, directed upward, was less than one square centimetre. On Saturday, the 25th, five loose flakes of mycelium had already made their appearance in it, and these subsequently became considerably developed. Thus, to the single flask which MM. Joly and Musset had declared would suffice to convince them, M. Pasteur might have added many others, for of the seventy-three vessels which he brought from the Montanvert and the Jura, he has still a great number untouched, none of which exhibit any alteration.

We now come to the description of M. Pasteur's series of experiments for the establishment of his view. Sixty glass flasks, each capable of containing from two hundred and fifty to three hundred cubic centimetres, were filled up to about one-third with a fermentescible liquid, prepared by boiling yeast in water in the proportion of one hundred grammes to each litre. The necks of the flasks were then drawn out into a fine tube, the liquid was boiled for about two minutes, and then each of the balloons was hermetically sealed. Fifty-six of the flasks bore this treatment without damage, four others were charged with the same liquid, and treated in the same way, except that their necks were merely drawn out and twisted, without being closed.

The next step in the experiments consisted in the fracture of the narrow necks of the flasks, so as to allow the air to rush into the interior, which it did with a whistling sound. This operation was performed by M. Pasteur, with all the precautions which he has always particularly insisted on. One of the flasks was found to have been imperfectly closed in the first instance, so that it had been gradually filled with air; it forms one of the first series of nineteen filled in the amphitheatre of the Museum. A second series of nineteen was filled with air on the outside of the dome of the amphitheatre, at its highest point; and the remaining eighteen, forming a third series, were opened at Bellevue, in the middle of a grass plot, near a clump of large poplars. After the access of air, the slender tubes of the necks were closed by the æolipyle. The whole of the flasks were then arranged in a convenient place in the Museum, together with three test-glasses, filled with the

limpid liquid employed by M. Pasteur. The very next day the liquid in these three glasses already showed indications of numerous Bacteria, and its muddy appearance contrasted with the perfect transparency of that contained in the flasks.

The results of the observations of the three series of closed vessels, up to the 20th of July, and again in November, are given by M. Balard, in three separate tables, and the final results are summed up as follows: —

"Of nineteen flasks of the first series, filled with air taken in the amphitheatre, there are only five in which some organic developments were manifested; fourteen remained unaltered.

"The second series of flasks, full of air taken on the dome of the amphitheatre, presents thirteen which remained without alteration, whilst only six gave origin to living beings. But the proportion changes considerably in the flasks filled with air at Bellevue; out of the eighteen of these vessels, sixteen were altered."

"If we regard germs as the cause of the developments produced in these experiments," says M. Balard, "we might be led to think that near a meadow, under trees, in the midst of these numerous sources for the production and dissemination of minute seeds of all kinds, the air would be more charged with them than in the heart of a town; and, as we have just seen, the results of our experiments are in accordance with this supposition." He adds the curious fact that, whilst nothing but vegetation was produced in the flasks filled with air in Paris, seven of the Bellevue vessels also contained infusoria.

The four flasks, with their necks drawn out and bent, but left open, were exhibited to the Academy in a perfectly unaltered condition at the time of the presentation of M. Balard's report. That gentleman calculates that, from the effect produced by changes of temperature upon these vessels, the air contained in them must have been renewed at least seven times in the course of the experiment. But as the entrance of the air would be effected slowly, it could deposit in the flexures of the tube any matters which might cause the development of organisms in the fluid. To ascertain whether this was really the case, the following experiment was made: The bent tube of a similar flask, which had been kept for three years by M. Pasteur, was sealed at its extremity with the blow-pipe. The flask was then violently shaken, so that the liquid contained in it moistened some parts of the tube. Within two days, numerous organisms made their appearance in the liquid, and especially in that retained in the tube.

"Thus," says M. Balard, "the facts observed by M. Pasteur, and disputed by MM. Pouchet, Joly, and Musset, are perfectly exact. Fermentescible liquids may remain without alteration either in contact with confined air, or in contact with air which is frequently renewed, and when, under the influence of this fluid, living organisms are developed in it, this development must not be attributed to the gaseous elements, but to solid particles of which the air may be freed by various means, as M. Pasteur has asserted."

The Commission also commenced some experiments with an infusion of hay, the liquid recommended by MM. Pouchet, Joly, and Musset, but as the period of the year declared by those gentlemen to be most favorable for such operations was already passed, their further prosecution has been postponed until the coming spring and summer. M. Balard states, however, that such results as were obtained last year seemed to be confirmatory of those of M. Pasteur's experiments. — *Reader*, 1865.

Dr. George Child read before the Royal Society a paper on the production of organisms in closed vessels, in which he states that Bacterians are produced "exactly under the circumstances in which M. Pasteur asserts that they do not exist. M. Pasteur, in his Memoir, speaks of examining his substances with a power of 350 diameters. Now my experience throughout has been that it is impossible to recognize these minute objects, with any degree of certainty, even with double that magnifying power. I can now have no doubt of the fact that Bacterians can be produced in hermetically sealed vessels, containing an infusion of organic matter, whether animal or vegetable, though supplied only with air passed through a red-hot tube, with all necessary precautions for insuring the thorough heating of every portion of it, and though the infusion itself be thoroughly boiled. It seems clear that either the germs of Bacterium are capable of resisting the boiling temperature in a fluid, or that they are spontaneously generated, or that they are not 'organisms' at all. I was myself somewhat inclined to the latter belief concerning them at one time; but some researches in which I am now engaged have gone far to convince me that they are really minute vegetable forms. The choice, therefore, seems to remain between the other two conclusions. Upon these I will not venture a positive opinion, but remark only, that, if it be true that 'germs' can resist the boiling temperature in fluid, then both parties in the controversy are working upon a false principle, and neither M. Pouchet nor M. Pasteur is likely at present to solve the problem of spontaneous generation."

The September and October numbers of the "Journal de l'Anatomie et de la Physiologie" contain the results of some experiments on spontaneous generation, by M. Al. Donné, which appear to the author favorable to this theory, although for a long time he has been one of its opponents. He has examined the result of exposing eggs to spontaneous decomposition during some weeks. He argued that, having thus an organized matter highly complex and naturally free from all floating atmospheric germs, — and as this matter contained in itself a certain amount of pure air, — it was in the best possible state to give rise, in its alteration, decomposition, and putrefaction, to infusoria, or animalcules, the ordinary result of the putrefaction of animal matter freely exposed to the air. With a substance naturally free from all foreign matter, and protected from exterior contact, like the egg in the shell, the conditions of a crucial experiment would be realized. Tried in this manner, the results were against the theory of spontaneous generation.

But the small quantity of air enclosed in the egg was not considered sufficient to determine the phenomena, and the experiments were tried again with certain modifications. The eggs were carefully washed, well dried, and then enclosed in a thick coating of cotton wool, taken out of a stove at 150° C. A fine sharp rod, previously heated to redness, was then inserted obliquely through the cotton, and the tip of the egg was pierced with a hole. The eggs were then put in a safe place, and covered with a bell-glass. In a few weeks' time the surface of the contents of the egg was covered with velvety-looking mould, white, gray, yellow, or green. Under the microscope, this was seen to consist of organized filaments and beautiful globules of different sizes. There was, however, no trace of living animalcules. Supposing that the presence of water was needed, as the viscosity of the contents of the egg might hinder their development, a little boiling water was put into the egg, covered with cotton. In two days, the substance was swarming with vibrios. The same experiments were then tried with hard-boiled eggs. The result, therefore, appears to be, that we can produce at will vegetable or animal beings in pure organic matter, without the intervention of germs from without. Water is necessary to the development of infusoria; and air is indispensable to the development of living beings of either kingdom.

During the year 1866, arguments, more or less convincing, have been accumulated on both sides of this question, so that it is impossible, at present, to decide in favor of or against the theory of spontaneous generation.

NATURE OF MUSCULAR IRRITABILITY, BY RICHARD MORRIS, M.D.

The subject was discussed before the British Association in 1866, under the following propositions: 1. That the property of irritability in muscle is capable of a high degree of exaltation above the normal standard, and that the highest degree of susceptibility is attained in cold bloods, long after death, or under conditions tantamount to death. 2. That the forces of the nerve and muscle, the neurility of the former, and the irritability of the latter, are not only independent of each other for their existence and maintenance, but actually possess an antagonistic relation, — that is to say, nerve tissue, instead of producing, is, when in action, constantly concerned in maintaining a condition of things which diminishes muscular irritability, and that not simply when it is engaged in the production of motion. 3. Conversely, that muscular tissue, relieved from the operation or influence of nerve tissue, gradually acquires exalted contractile powers either in the presence or absence of the blood. 4. That the blood, or the nutritional plasma derived therefrom, not only furnishes the materials by which muscular irritability is maintained, but is likewise the determining cause of that polar arrangement of the muscular molecules, which maintains or restores the elongated or relaxed state. These propositions were sustained by constant reference to experiment, much consideration being devoted to the

proof that the principle of volition, when in operation, exhausted the muscular and nervous forces, and produced the condition which, in common parlance, is recognized as fatigue; and that, in the absence of volition, — or, what amounted to the same, nerve in action, — the forces of the system were considerably increased; hence the use of sleep was obvious. The nervous system was not only concerned in exhausting the muscular during the production of motion, but constantly while maintaining the normal position of the animal. He said that profound etherization, sleep, fainting, and death, were different degrees of what might be called functional neural paralysis, in contradistinction to purely muscular, a form in which the special life of muscle was diminished or destroyed. The best condition for the exaltation of the peculiar life of muscle was the absence of nerve, as then the forces were not expended as fast as the chemical reactions between the muscular tissue and the blood led to their generation. In support of the final proposition, many experiments were adduced which clearly showed that the relaxed or elongated condition of the muscles was maintained by the blood, and that the blood, under all circumstances, opposed the state of contraction which it was the special function of nerve to bring about. The various affections of muscular fibre, as they had been observed in the author's experiments, were then described. 1. A muscle may exist in the elongated or uncontracted state, with all its dynamical powers perfect; this is its normal condition, in the absence of volitional effort. 2. It may exist in this state, when deprived of all dynamics, or, in other words, in the absence of irritability. Both these conditions of relaxation may be associated with softness or flaccidity of the muscular structure; the former necessarily so, the latter not, as the fixity of rigor may prevail. Again, a muscle may exist in a state of complete contraction, both in the presence and absence of its dynamics; in a state of softness, or in a hard, coagulated state. As with the state of elongation, so with that of contraction, the truly dynamical state is one of softness. Properly speaking, irritability is no more the tendency which a muscle exhibits to contract than the disposition it exhibits to elongate, subsequently to contraction; in fact, a comprehensive definition must include both these conditions; neither are either of these states to be considered, as far as muscle alone is concerned, as conditions of rest, for they are both active states, so long as the muscle is a vital structure, and both inactive when the dynamics of muscle are absent. The attractive state of the muscular molecules, which represents contraction is the condition in which force is exhausted by the apposition of unlike polarities; while, in the state of elongation, being that in which every molecule is opposed to every other, force may be accumulated. In proportion to the amount of force accumulated in the molecules will be the intensity of their contractive or elongative energy, and also in the ratio of their charge will be their proclivity to disturbance, or, in other words, susceptibility to stimuli. The author combated the view of Dr. Radcliffe, who regarded the contraction of a muscle as taking place simply on the withdrawal of some elongating force, and

showed, by an analysis of the various conditions under which muscle existed, that no theory met the case so well as that of Du Bois Raymond, in which the molecules of muscle were regarded as centres of electro-motor action, arranged in a dipolar series, — in a word, one fluid, two forces or poles, — the repulsive polar attitude maintained by the blood, and the attractive inducible by nerve and external stimuli.

THEORY OF MUSCULAR ACTION.

Professor Heidenhain, of Breslau, has recently published a little work on "The Production of Heat, etc., during Muscular Action," an account of which may perhaps prove not uninteresting to our readers, since it bears closely on the application to physiology of the doctrine of the conservation of force. A few words of introduction, however, will be needed.

A piece of dead flesh represents, by virtue of its chemical elements, a certain amount of "latent energy," which, in the natural process of decay, is gradually set free as "actual" force in the form of heat. The living muscle, in like manner, also represents a certain amount of "latent" energy. During life, a metamorphosis (oxidation) of the muscular tissue is continually going on, and, consequently, a quantity of "latent" energy is continually becoming "actual." As long as the muscle is inactive, is at rest, does not contract, the forms assumed by the liberated energy are, as far as we know, those of electricity and heat. In every living muscle there are "muscle-currents," and there is a certain amount of heat given out. But when the muscle enters into a state of activity, when it contracts, another element is introduced, viz., the mechanical work effected by the shortening of the fibres. In every muscular contraction there are, therefore, four things to be considered, — the chemical action, and the production of electricity, of heat, and of mechanical work. Any comprehensive theory of muscular action must be able to show how these are related to each other.

Is the chemical action natural to the muscle increased, or not, during contraction?

If so, what becomes of the surplus of "actual" energy thus liberated? Does it all go over into mechanical work, or partly into heat and electricity?

If not, is there any evidence of the direct conversion, during the act of contraction, of heat or of electricity, or of both, into mechanical work, or of the diversion to the same end of some part of the force arising from chemical action, at the expense of some amount of heat or electricity?

That, during contraction, there is really an increase of chemical action, has been generally admitted since the well-known experiments of Helmholtz. Some, indeed, have spoken as if they thought that chemical action occurred during contraction only; clearly an erroneous conception. Voit has adopted what may fairly be called an error of the opposite kind, in concluding that there is no increase of chemical action during contraction, because no notable

increase takes place in the excretion of urea after even violent exercise. Whatever may prove to be the fate of the nitrogenous elements of muscular tissue, there can be scarcely any doubt but that there is a large extra consumption of hydro-carbonaceous material during muscular action. It is just possible to conceive that the increase of waste products which can be observed in a muscle, after a series of contractions, may belong not to the time of contraction itself, but to the stage immediately following,—may indicate, as it were, a kind of reaction following the shock of the stimulus; but there is not the shadow of a proof that such is really the case. It may be taken for granted that muscular contraction means increase of chemical action, and, therefore, increase in the total amount of "actual energy" issuing from the muscle.

With regard to one of the forms of energy proper to muscles,—viz., electricity,—we have known for some time past, that during contraction, a remarkable change occurs in the "muscle-current." It is generally spoken of as "the negative variation," and has been made the basis of Voit's, as well as of Dr. C. B. Radcliffe's, views on the subject we are dealing with.

The production of heat during muscular contraction has received much attention during the last few years. We need not specify the various observations here; and Heidenhain contends that the delicacy of his own arrangements have enabled him to detect and avoid the errors of his predecessors. Frogs' muscles were used for the experiments. His results are briefly these:—

1. During a contraction (that is, a single contraction, not a tetanus), heat is always given out, the index of the apparatus showing a rise of temperature varying from .001° C to .005° C.

2. When a muscle (suspended by one end, and with a weight attached to the other) is stimulated by a stimulus of constant strength, and loaded with a variable weight, both the heat given out and the work done (weight + heat) increase with an increase of the weight up to a certain limit (determined by the condition of the muscle), beyond which they both sink.

3. When a muscle is stretched by a weight hung at one end, but is prevented from contracting by being fixed at both ends, the amount of heat given out (on the application of a stimulus of the same strength) varies directly as the extending weight, up to a certain limit.

4. When a muscle, excited by the same stimulus and bearing the same weight, is in one case allowed to contract freely, but in another prevented from so doing by being fixed at both ends, the amount of heat given out on the stimulus being applied is much greater in the latter instance than in the former.

5. When a muscle is connected with a small constant weight and a large variable one, in such a way that it always bears the strain of the former, but that of the latter only at such times as it contracts, both the heat given out and the work done (with the stimulus of same strength) vary directly as the larger weight.

6. When the experiment is repeated with the alteration that the smaller weight, whose strain is continually borne, is made variable, and the larger one constant, both heat and work vary directly as the variable weight.

Leaving electricity on one side, and dealing, therefore, only with heat and work as the "actual" forces set free during contraction, the above experiments clearly lead to the conclusion that the sum total of the forces becoming "actual" during contraction depends on, is a function of the tension of the muscular fibre (before and) during that act. Heidenhain obtained similar results in experimenting with tetanus. To say that the sum total of forces set free during contraction is influenced by the tension of the fibres, is, of course, to say that the quantity of latent energy consumed, the amount of chemical action concerned in the act, is influenced by the same means. We ought, therefore, to find an increase of waste products in muscles which are made to contract under tension. Taking one such waste product as an index of the others, Heidenhain satisfied himself not only that there was a production of carbonic acid during contraction, but also, that the amount of it was in proportion to the sum total of force becoming "actual," and was a function of the tension of the fibres.

That the mere, so to speak, physical extension of a muscular fibre should have a marked influence on the metamorphosis of its substance, has been for a long time practically admitted, though the matter had never been rigidly ascertained before the investigations of Heidenhain. The subject is not lacking in practical importance; but it is chiefly of interest, inasmuch as it bears very closely on the general theory of muscular action. — *Reader.*

SOURCE OF MUSCULAR POWER.

Twenty years ago, physiologists would have attributed the source of muscular power to something peculiar, developed by living animals, and termed *vital force.* The progress of scientific discovery, however, rapidly dissipated the very crude notions which then existed regarding this mysterious agency. We now know that an animal, however high its organization may be, can no more generate an amount of force capable of moving a grain of sand than a stone can fall upward, or a locomotive drive a train without fuel. All that such an animal can do is to liberate that store of force, or potential energy, which is locked up in its food. It is the chemical change which food suffers in the body of the animal that liberates the previously pent-up forces of that food, which now make their appearance in the form of actual energy, — as heat and mechanical motion. From food, and food alone, comes the matter of which the animal body is built up; and from food alone come all the different kinds of physical force which an animal is capable of manifesting.

The two chief forms of force thus manifested are heat and muscular motion, or mechanical work. These have been almost universally traced to two distinct sources, — the heat to the oxidation of the food, and the mechanical work to the oxidation of the muscles. This doctrine, first promulgated by Liebig, has been within late years adopted by most physiologists, and has been taught in all the text-books treating of the subject. The proximate constituents of food have been frequently divided into two

groups, — carbonaceous or non-nitrogenous, such as fat, starch, sugar; and the nitrogenous, such as fibrin, albumen, and casein, — the former class being regarded as comprising simple heat-givers, that is to say, substances that furnish material for oxidation in the process of respiration, and thus maintain the temperature of the body; the nitrogenous constituents being the flesh-formers, or substances building up the muscles of the body, through which motive force is exerted. The exercise of a muscle being accompanied by a proportionate destruction or oxidation of its tissue, it follows that the plastic or flesh-forming constituents of food should bear a relation to the amount of muscular work performed. This theory, namely, that mechanical work, *i. e.*, muscular exertion, is dependent on the destruction of muscular tissue, has been supported by Ranke, Playfair, Draper, and others; and, as we have already stated, it has been generally taught up to the present time. Nevertheless, it has not escaped challenge. Immediately after its promulgation, Dr. J. R. Mayer wrote, "A muscle is only an apparatus by means of which the transformation of force is effected, but it is not the material by the chemical change of which mechanical work is produced." This assertion he supported by several cogent arguments. Other physiologists also expressed similar opinions. Messrs. Lawes and Gilbert advocated a like view, basing their opinions on their own elaborate and carefully-executed experiments on the feeding of cattle.

Some very important researches upon this subject have been recently published by Drs. Fick and Wislicenus, Professors at the University of Zurich, and also by Dr. Frankland in London. An account of these experiments was given in a lecture delivered at the Royal Institution by the latter chemist during last session.

It is probable that these investigations will very materially affect the present condition of physiological science, tending, as they do, to entirely change the ideas hitherto entertained respecting the relation of food to the requirements of the animal body.

The question is to determine whether the muscle is merely the apparatus by which animal motion is produced, or whether it furnishes both the apparatus and the force to work it. In order to solve this problem by experiment, there are three things necessary to be determined. First, the amount of force or energy generated by the oxidation of a given amount of muscle in the body; secondly, the amount of mechanical force exercised by the muscles of the body during a given time; thirdly, the quantity of muscle oxidized in the body during the same time.

It follows that if the amount of mechanical force exercised by the muscles be greater than the amount of the substance oxidized could furnish, the force of the muscles is not exclusively derived from their own substance. When muscle is consumed in the body, its nitrogen appears principally in the form of urea. Hence the amount of energy derived from the oxidation of muscle in the body will be expressed by the heat of combustion of the muscle itself, minus the heat of combustion of that amount of urea which the muscle would furnish when consumed in the body. This difference of heat was determined by Frankland, who found that to

convert one gramme of dry muscle into urea, as much heat was evolved as would, when converted into mechanical force, be sufficient to raise a hundred weight to the height of one hundred and thirty-two feet.

The second of the required data, viz., the actual work performed in a given time by the muscles, was ingeniously determined by Fick and Wislicenus by the elevation of the body itself. For this purpose they ascended the Faulhorn, a mountain of the Bernese Alps, 6560 feet high, near the lake of Brienz, whose regular slopes rendered it well adapted for their experiment. The height of the mountain, multiplied by the weight of the body of each experimenter, gave the amount of external work performed, and to this was added the estimated internal work of the circulation and respiration.

The third datum — the amount of muscle consumed — was given as a maximum by the amount of nitrogen excreted by the kidneys. This amount being determined by analysis, the amount of muscle consumed is readily calculated, since every 15.6 parts of nitrogen indicate 100 parts of muscle destroyed. The excreted nitrogen was determined in the experiments of Fick and Wislicenus with every possible care; and in order that there might be no source of loss, the amount excreted for six hours after the ascent was taken into account.

As a final result of their investigations, they found that the muscle consumed, even with the most liberal allowance for all possible chance of error, would not account for the work performed. Even under the most favorable interpretation, and neglecting all the internal and external work that could not be accurately measured, it was found that the combustion of the muscles themselves would not account for a third of the work performed.

The calorimetrical determination of the actual energy evolved by the combustion of muscle and of urea in oxygen have been made by Dr. Frankland; and the results show that the amount of muscle destroyed by the former gentlemen during their ascent would not account for one-half of the force required to lift them to the summit of the mountain. Taking the average of the two experiments, and making several necessary allowances, Dr. Frankland calculates that scarely one-fifth of the actual energy required for the work performed could be obtained from the amount of muscle consumed.

Examining a number of previous experiments of a like kind, Dr. Frankland finds them all confirmatory of the same thing. Thus, he gives a summary of three sets of experiments made by Dr. E. Smith, by the Rev. Dr. Haughton, and by Playfair, in which in each case the force expended is in excess of that derivable from the muscle oxidized.

The following are the conclusions deduced by Dr. Frankland from his experiments: —

"1. The muscle is a machine for the conversion of potential energy into mechanical force.

"2. The mechanical force of the muscles is derived chiefly, if not entirely, from the oxidation of matters contained in the blood, and not from oxidation of the muscles themselves.

"3. In man, the chief materials used for the production of muscular power are non-nitrogenous; but nitrogenous matters can also be employed for the same purpose, and hence the greatly increased evolution of nitrogen under the influence of a flesh diet, even with no greater muscular exertion.

"4. Like every other part of the body, the muscles are constantly being renewed; but this renewal is not perceptibly more rapid during great muscular activity than during comparative quiescence.

"5. After the supply of sufficient albumenized matters in the food of man to provide for necessary renewal of the tissues, the best materials for the production, both of internal and external work, are non-nitrogenous matters, such as oil, fat, sugar, starch, gum, etc.

"6. The non-nitrogenous matters of food, which find their way into the blood, yield up all their potential energy as actual energy; the nitrogenous matters, on the other hand, leave the body with a portion (one-seventh) of their potential energy unexpended.

"7. The transformation of potential energy into muscular power is necessarily accomplished by the production of heat within the body, even when the muscular power is exerted externally. This is, doubtless, the chief and probably the only source of animal heat."

Dr. Lyon Playfair, at the 1866 meeting of the British Association, gave the results of experiments which had been tried with feeding rats and dogs for a considerable time on meat totally free from fat, showing that nitrogenous substances could be made into muscular force. With regard to the amount of nitrogenous matter naturally consumed in food, it appeared that in the fare of soldiers of all countries the amount was 4.2 oz. for each man. The ordinary amount of work that a soldier performed might be estimated as raising 48,000 kilometres to the height of a metre. There had been much more done by the soldier, more especially during the late Prussian war, and the forced marches of Sherman. In the discussion that followed, Dr. Edward Smith contended, 1. That there was no *prima facie* ground for the division of foods by Liebig into heat-formers and flesh-formers, since the latter contain carbon and hydrogen like the former, which must be available for the production of heat. 2. That his experiments, as well as those of Voit, had proved conclusively that the emission of nitrogen was no measure of muscular waste, since with the most severe exertion the excretion of urea scarcely at all increased. 3. That the emission of carbonic acid is the true measure of muscular action, since he had proved in 1860 that the finger could not be kept in motion without increasing the emission of that product, and the emission increased as the exertion increased. He had in the same year called attention to this as the true measure of muscular action, and was the first to do so. 4. That whilst the experiments quoted by Prof. Frankland, to show that the consumption of carbon and hydrogen was the source of muscular power — those of Fick and Wislicenus — were inconclusive, there was much reason to believe that the conclusions were not far wrong. They were

inconclusive, because the experimenters had taken the period of emission of urea to represent that of its formation; because the emission is at all times dependent upon the excretion of water by the kidneys, and must in these experiments have been lessened during exertion by the fact of much of the fluid passing out by the skin and so much less by the kidneys; because no accurate basis of comparison was obtained; and because the duration of the whole inquiry was too short.

This view, that in the combustion of the carbon and hydrogen derived from the food is the source of muscular power, suggests radical changes in the diet necessary for laboring persons. The function of nitrogenous food being doubtless that of providing fresh muscular tissue to replace that constantly lost by waste and decay, it is estimated that this would be furnished by about four ounces of dry albumen in the twenty-four hours; and, this amount being supplied, the remainder of the food necessary to supply the body with its working fuel may be either of the starchy or fatty classes. Animal flesh is disadvantageous as working food, being incompletely burned in the body, with a consequent loss of energy, as the waste urea it produces is really a combustible body; fats, sugars, etc., are, on the contrary, completely consumed within the body.

From a table given by Dr. Frankland, it appears that the dry farinaceous cereals possess, in a striking degree, advantages, as a source of muscular power, over the animal foods; and both are very greatly surpassed by the fats and fatty substances, such as cocoa or cheese. This explains the remarkable strengthening power of cod-liver oil. Alpine and Arctic travellers well know the nourishing properties of fat and sugar. The extensive use of oat-meal, as a cheap source of muscular power, is founded on true physiological principles; and the high-priced animal foods, having comparatively small force-value, are very uneconomical articles of diet. But, as the labor of digestion is of itself a considerable source of internal work, it may happen that the ready digestibility of an article of food may more than compensate for its otherwise inferior value as a source of force.

Those interested in this subject are referred to the Reports of the British Association for 1866, "American Journal of Science" for November, 1866, "Franklin Journal" for November, 1866, and the "Intellectual Observer" for July, 1866.

SUGAR PREVENTING THE GENERATION OF ANIMALS.

Mr. Henry Tanner, Professor of Rural Economy in Queen's College, Birmingham, says: "I have every reason to believe that the action of sugar, in its various forms, is most important in its influence on the generative system; and I think there is just cause for considering that any animal may by its use be rendered incompetent for propagating its species. Since my attention has been drawn to this fact, numerous instances have come under my observation tending to confirm this opinion. From among the cases which I could mention, it will probably be sufficient for me

to state that of a breeder of some eminence, who, with a view to an improvement in the condition of his herd, added molasses to the dry food he gave to his stock. It certainly produced the result he anticipated, for their appearance and general condition were most satisfactory; but this was accompanied by an influence he had never expected, for his stock, which had always realized high prices as breeding stock, now, with very few exceptions, proved to be valueless for that object, male and female being alike sterile. As soon as this was discovered, the supply of molasses was stopped. But while the animals which had not been under its influence maintained the original character of the herd, as being good breeding stock, it is very doubtful if any of the stock which had been fed for any length of time upon food mixed with molasses ever regained their breeding powers. It is more than possible that a fatty degeneration of the ovaries took place, from which they would but slowly recover under any ordinary treatment. In another case, where molasses had been used for some heifers which were fattening, it had the effect of suppressing those periodical returns of restlessness which prevent heifers feeding as well as steers; and it kept them steadily progressing during the whole period of their fattening, and the result was highly satisfactory. If, therefore, upon further trial, we find sugar influential in checking the reproductive functions, we can, at any rate, exercise a proper discretion in its use; and, while avoiding it for breeding animals, we may encourage its employment when cows or heifers have to be fattened."

DIGESTION OF ANIMAL FOOD.

Recent discoveries tend to prove that gastric juice does not simply liquefy fibrin and casein, but that it acts also on albumen in such a way as to modify its molecular condition, and thereby its chemical properties. If the albumen of an egg be injected into the jugular vein, it passes unaltered to the blood, for it is found in the secretions of the kidneys. It follows that albumen of the egg must undergo a molecular change to render it fit to become assimilated; and we may assume, therefore, that it experiences the same change in the stomach under the influence of the ferment, called pepsin. Until recently, scientific men had assumed that there must be an identity between albumen, fibrin, and casein, which are the chief elements representing animal food, still they have not been able to demonstrate their convertibility one into the other. Mr. Smee has accomplished this, and has reversed the theory previously entertained as to what takes place during digestion; for he has established that fibrin, or the clot of blood; casein, or the curd of milk; and albumen, the serum of blood, are convertible into one fluid, which he has called albuminose, or pectose. Mr. Smee has succeeded, then, in reversing the problem, and has shown that albumen may be converted into fibrin, and probably casein. To effect this interesting change, he proceeds as follows: He passes a current of pure oxygen gas through a solution of albumen of blood or egg,

slightly acidulated with acetic acid, and at a temperature of blood heat, or of 98° to 100° and after several hours, a mass of fibrin appears, the production of which is facilitated by bringing into play the action of an electric current. If, instead of an acid solution of albumen, Mr. Smee employed a weak alkaline solution of the same substance, it became transformed into a peculiar substance, known under the name of chondrin.

THE RAPIDITY OF ABSORPTION. BY DR. H. BENCE JONES.

It occurred to the author that it might be possible to trace the passage of substances from the blood into the textures of the body by means of the spectrum analysis; and, with the assistance of Dr. Dupré some very remarkable results have been obtained.

Guinea-pigs have chiefly been used for the experiments. Usually, no lithium can be found in any part of their bodies. When half a grain of chloride of lithium was given to a guinea-pig for three successive days, lithium appeared in every tissue of the body. Even in the non-vascular textures, as the cartilages, the cornea, the crystalline lens, lithium would be found.

Two animals of the same size and age were taken; to one was given three grains of chloride of lithium, and it was killed in eight hours; another had no lithium; it was also killed, and when the whole lens was burnt at once, no trace of lithium could be found. In the other, which had taken lithium, a piece of the lens, one-twentieth of a pin's head in size, showed the lithium; it had penetrated to the centre of the lens.

A patient who was suffering from diseased heart took fifteen grains of citrate of lithia thirty-six hours before her death, and the same quantity six hours before her death. The crystalline lens, the blood, and the cartilage of one joint were examined for lithium; in the cartilage it was found very distinctly; in the blood exceedingly faintly; and when the outer lens was taken, the faintest possible indications of lithium were obtained.

Another patient took ten grains of carbonate of lithia five hours and a half before death; the lens showed very faint traces of lithium when half the substance was taken for one examination; the cartilage showed lithium very distinctly.

Dr. Jones expects to be be able to find lithium in the lens after operation for cataract, and in the umbilical cord after the birth of the fœtus.

APPEARANCES OF GOOD AND BAD MEAT.

Dr Letheby, in a report on the cattle plague, gives the following characters of good and bad meat, which are especially interesting: "Good meat is neither of a pale pinkish color, nor of a deep purple tint. The former is indicative of disease, and the latter is a sign that the animal has died from natural causes. Good meat has also a marbled appearance from the ramifications of little veins of intercellular fat; and the fat, especially of the internal organs, is hard and suety, and is never wet; whereas that of the

diseased meat is soft and watery, often like jelly or sodden parchment. Again, the touch or feel of healthy meat is firm and elastic, and it hardly moistens the fingers; whereas that of diseased meat is soft and wet—in fact, it is often so wet that the serum runs from it, and then it is technically called wet. Good meat has but little odor, and this is not disagreeable; whereas diseased meat smells faint and cadaverous, and it often has the odor of medicine. This is best observed by cutting it and smelling the knife, or by pouring a little warm water upon it. Good meat will bear cooking without shrinking, and without losing very much in weight; but bad meat shrivels up, and it often boils to pieces. All these effects are due to the presence of a large proportion of serum in the meat, and to the relatively large amount of intercellular or gelatinous tissue; for the fat and true muscular substance are to a greater or less extent deficient. If, therefore, 100 grains of the lean or muscular part of good meat are cut up and dried at a temperature of boiling salt water (224° F.), they lose only from 69 to 74 grains of their weight; but if diseased meat is thus treated, it loses from 75 to 80 per cent. of its weight. I find that the average loss of weight with sound and good beef is 72.3 per cent., and of mutton 71.5 per cent., whereas the average loss of diseased beef is 76.1 per cent., and of diseased mutton 78.2 per cent. Even if it be dried at a higher temperature, as at 266° F., when all the moisture is expelled, and when good meat loses from 74 to 80 per cent. of its weight, the proportion of loss in bad meat is equally as great. Other characters, of a more refined nature, will also serve to distinguish good from bad meat. The juice or serosity of sound flesh is slightly acid, and it contains an excess of potash salts, chiefly the phosphate; whereas diseased meat, from being infiltrated with the serum of blood, is often alkaline, and the salts of soda, especially chloride and phosphate, abound in it. Lastly, when good meat is examined under the microscope, the fibre is clean and well defined, and free from infusorial creatures; but that of diseased meat is sodden, as if it had been soaked in water, and the transverse markings are indistinct and far apart; beside which, there are often minute organisms, like infusorial bodies. These are very perceptible in the flesh of animals affected with the cattle plague, and Dr. Beal has described them as entozoa-like objects. They differ altogether from the parasites which constitute the trichina disease, and the measles of pork. How far the use of diseased meat affects the human constitution is unknown. In those cases where certain parasite diseases exist in animals, there is no doubt of its injurious nature; for the tape-worm, the trichina, and certain hydatid or encysted growths are unquestionably produced by it. Experience also points to the fact that carbuncle and common boils are in some degree referable to the use of the flesh of animals affected with pleuro-pneumonia; and occasionally we witness the most serious diarrhœa and prostration of the vital powers after eating diseased meat. It is, therefore, safest to forbid its use; and it is at all times best to guard against the possibility of injury by having meat well cooked. It should be so cooked that the very centre

of the joint should be exposed for some time to the temperature of 212° Fahrenheit. The instructions of Liebig in this particular are hardly safe; for although a temperature below that of boiling water may coagulate albumen and develop the flavors of cooked meat, it may not insure the destruction of dangerous parasites. It is therefore better to have the meat a little overcooked than otherwise."—*London Journal of Pharmacy.*

HORSE-FLESH AS FOOD.

The experience of the last five years on the continent of Europe proves conclusively that horse-flesh is a wholesome and desirable article of food. The taste for horse-flesh is increasing in Paris. There are at present in the capital seven butcheries for the sale of that commodity, and which dispose of about forty thousand pounds weight per week. The annual consumptiom may therefore be estimated at one thousand tons, or more than ten times the quantity of meat distributed to the poor in the twenty bureaux de bienfaisance. So, far horse-flesh has been exempt from the octroi duty, and sells at from five sous to one franc the kilogram, of two pounds.

Recently a mart for horse-flesh as human food was opened at Orleans. A similar establishment in Paris has now gone on for some time past with increasing success; and by applying the same precautionary measures which have succeeded in the metropolis, the use of horse-flesh may be expected to attain popularity as human food in Orleans equal to that which it is alleged to hold in the great capital for culinary science. It is admitted on all hands that all the horses offered for slaughter as human food are not fit for that purpose, and that the absence of strict supervision in this matter on the part of the authorities might lead to dangerous consequences. It appears that this is well understood both by the hippophagists and the police of Paris. The meat, before appearing for sale, has been examined and marked as sound by veterinary experts appointed for the performance of that duty. The Parisian public evidently place some faith in the security afforded by this system of certification, for it is not the very poor only who buy the horse-flesh in Paris, but well-to-do working people, and even latterly the middle classes. It is on the score of cheapness that horse-flesh is offered to the Orleans public at forty centimes the kilogram. Beef, mutton, and veal are now sold here at an average price of one hundred and forty centimes the kilogram. Omitting fractional parts, therefore, it may be stated that the price per English pound of horse-flesh is two pence; and of beef, mutton, and veal, seven pence.

THE PHENOMENA OF DEGLUTITION.

Prof. Krishaber, who has been experimenting with the autolaryngoscope with a view to discover the method by which swallowing is effected, has arrived at several conclusions, the most important of which may be tabulated as follows:—

1. In the act of deglutition, the alimentary mass passes through one of the pharyngeal arches, over one of the sides of the epiglottis; by this means it reaches the œsophagus at the very moment when, by the contraction of the muscles, the pharynx is contracted.

2. The deglutition of liquids is effected in a somewhat similar manner, these passing very often over the epiglottis, in which they differ from solids.

3. A very small quantity of the liquid passes over the edge of the epiglottis, and thus moistens the mucous membrane of the larynx and the cords of the voice.

4. In gargling the throat, the larynx being then much opened, a large quantity of liquid escapes into the vocal organ.

5. One may easily bear a piece of food in the air-passages, that is to say in the larynx, near the vocal cords, and even in the interior of the windpipe.

6. The sensibility of the windpipe to the touch of foreign bodies is far less than that of the larynx.

7. Hard and cold bodies, such as a probang, are never tolerated by the respiratory passages, although soft bodies which adhere to the mucous membrane, and have the same temperature as it, may remain in the trachea for several minutes without producing any repulsive effect.

The contraction is automatic, and produced by reflex action. This, in turn, is due to the sensation caused by the contact of the foreign substance with the membrane lining the regions of the glottis, but more especially under the epiglottis; this membrane, therefore, appears to play the part of a special sensory organ.

EXECUTION BY HANGING.

Prof. Haughton communicates a paper to the "Philosophical Magazine" "On Hanging, Considered from a Mechanical and Physiological Point of View": —

"In hanging, death is either caused by pressure on the jugular veins, by asphyxia, caused by stoppage of the windpipe, or by shock of the medulla oblongata, caused by fracture of the vertebral column. In the latter case only is death instantaneous. According to the original form of death punishment in England, the hanging was used as an anæsthetic, preparatory to the drawing and quartering of the criminal. The 'short drop' of three or four feet, as used in this country, is quite insufficient to cause instantaneous death, and is, moreover, often productive of some very painful 'scenes at the scaffold.' Prof. Haughton has ascertained, from his own observations, that the shock of a ton dropped through one foot is just sufficient to fracture the anterior articulating surfaces of the second vertebra at their contract with the atlas; and that this fracture allows the shock to fall upon the medulla oblongata so as to produce instantaneous death. Thus, a criminal weighing 160 lbs. should be allowed a 14 feet drop ($160 \times 14 =$ 2,240 lbs.). It is the practice in Ireland to use a drop of nearly this length. Although death takes place immediately that the

criminal arrives at the bottom of the drop, yet the second or so which he takes to fall is, doubtless, one of extreme mental anguish, to avoid which the author gives a rule for producing instantaneous death by the American method. This consists in suddenly lifting the criminal into the air by means of a great weight attached to the other end of the rope fastened round his neck; the rope passes over a pulley placed vertically over the patient, and at a given signal the weight falls through a regulated height, lifting him suddenly into the air. By properly proportioning the weight and the distance through which it is allowed to fall, the 'chuck' produces instant death."

CONSANGUINEOUS MARRIAGES.

M. Rambosson communicated to the French Academy, in 1866, a paper on this subject: —

There are two very different opinions on this subject. One set of observations goes to show that the offspring of such marriages are, by that fact alone, condemned to an almost inevitable degeneracy, and that the union of individuals of the same blood may lead to the extinction of families. According to another set, such marriages entail no deterioration at all on the offspring; on the contrary, they preserve and ameliorate races. Hence some have deduced the fact that consanguinity in itself is perfectly innocuous, and can only help to perpetuate heredity. Supposing the two parents to be perfectly sound, their union will have no more tendency to produce disease in the offspring than if they were perfect strangers in blood to each other. Others again assert that in man, as in other animals, the intermarriage of blood relations increases the heredity both of good and bad qualities to the highest point possible; so that if any weakness exists in a family, the intermarriage of its members will multiply that weakness in an alarming degree. A third party observe that particular tendencies, when once developed, by diet, or by any other cause, in individuals, may be multiplied and perpetuated in a family, and then in a race by consanguineous marriages. So that a tendency in individuals becomes thus a realized fact in their offspring. The author proceeded to call attention to some facts which he thought had been lost sight of by these partisans. Man, he observed, was infested with more maladies than all other animals put together; so that even the very healthiest carry along with them always the seeds of some disease, or the tendency to some affection. When a man has recovered from any malady, he is likely to transmit it to his posterity. Now a malady is often the consequence of those daily conditions which give individuals who live together a sort of family air; so that it would be very difficult to find the members of any one family, or even very near relations, who are not liable to have tendencies to common disorders. Those, therefore, who have argued in favor of consanguineous alliances from the example of animals, have omitted important elements in the calculation. The instinct of animals is also a surer guide in matters of diet, and more readily followed,

than the taste or caprice of man. We must, therefore, be very careful in applying to man the principles of zoötechny. — *Reader.*

COLOR OF MAN.

Dr. John Davy read a paper on this subject, before the British Association, in 1866.

After enumerating the varieties of color of the human races, and their connection with latitude and climate, he considered the probable causes to which the difference of color may be referred. Of these he placed first, exposure to the sun's rays; it being an established fact, expressed in ordinary term by "sun-burn," that the sun's rays acting on the skin have a darkening effect; next, warmth of climate and an average high temperature throughout the year, under the influence of which there appears to be a tendency to accumulation of carbon in the system, as indicated by the little difference of color of the arterial and venous blood under exposure to a high temperature. An explanation of certain exceptional instances was next offered; as of the darker hue of the Esquimaux, to exposure to the sun's rays during that portion of the year that the sun in the Arctic regions is constantly above the horizon; and during the other portion, their winter, to their living shut up in a close impure air, and to their food being chiefly of a kind abounding in carbon and hydrogen; or, taking an opposite instance, as that of mountaineers, who, though much exposed to the sun, are commonly fairer than the latitude they inhabit would seem to warrant, to their blood being better aerated from the purer air inhaled and the active exercise they take, producing an accelerated action of the heart, and a more rapid flow and circulation of the blood. Further, he adverted to hereditariness on atavism, as deserving of attention in considering the color of races, and more especially its importance as to the great question of unity or difference of races *ab origine;* for, if climate should be found to have greater effect than blood in modifying color, unity might be inferred, and *vice versa.* In conclusion, he dwelt on the connection of good color and a fine complexion with health, to which nothing can contribute more than pure air, and exercise in the open air.

PHENOMENA OF FREEZING IN ANIMALS.

The following are the results of a long series of experiments by M. Pouchet, in reducing the bodies of animals to the temperature at which freezing takes place. 1. The first phenomenon produced by cold is a contraction of the capillaries to the degree that a blood globule cannot enter. 2. The blood globules are completely disorganized. 3. Every completely frozen animal is entirely dead, and cannot be reanimated. 4. When only a part is frozen, it is destroyed by gangrene. 5. If the part frozen be not extensive, and only a few disorganized blood globules pass into the circulation, the animal may recover. 6. If, however, the part frozen be of considerable extent, the mass of altered globules thrown into

the circulation, when the part is thawed, soon kills the animal. 7. A half-frozen animal, therefore, may live a long time if kept in that state, as the altered globules do not get into the circulation; but it quickly dies when the frozen part is thawed. 8. In all cases of death from freezing, the fatal result is due to the alteration of the blood globules, and not to any effect on the nervous system. 9. The less rapidly, therefore, a frozen part is thawed, the more slowly the altered globules enter the circulation, and the greater are the chances of the animal's recovery.

PERIOD OF GROWTH IN MAN.

Prof. B. A. Gould, from statistics derived from the register of two and a half millions of men in the United States Army, has brought out the remarkable fact that men attain their maximum stature much later than is generally supposed. This takes place commonly at 29 or 30 years of age; but there are frequent instances of growth until 35, not very noticeable, — a yearly gain of a tenth of an inch perhaps, still a growth. After 35 the stature subsides in similar proportions, partly perhaps from the condensation of the cartilages, partly because of the change in the angle of the hip-bone. The age for maximum stature comes earliest to the tallest men, as if it were the necessity of unusual development. Foreigners were shorter than men of native birth. The heights of men seemed to depend on the place of enlistment. A Massachusetts man enlisting in Iowa was an inch taller than if he had staid at home.

As we go west, men grow taller. One man measured more than 6 feet 10 inches. Out of one million, there were five hundred thousand who measured more than 6 feet 4 inches; but men of such stature do not wear well. In Maine, men reached their greatest height at 27, in New Hampshire at 35, in Massachusetts at 29, in New Jersey at 31. The tallest men, of 69 inches, come from Iowa. Maine, Vermont, Ohio, Indiana, Minnesota, and Missouri, give us men a little over 68; and the average of all shows the Americans to be "a very tall people."

THERAPEUTICAL ACTION OF MINERAL WATERS.

Though the remedial property of mineral waters be established, their *modus operandi* is as yet hardly ascertained, and is at present the subject of a very animated controversy in the French Academy, between M. Scoutetten and certain other savants. M. Scoutetten details a number of experiments and conclusions, from which we extract the following: 1. When platinum-electrodes are placed in ordinary water, contained in vessels of glass or porcelain, no trace of dynamic electricity is apparent. 2. When the same experiment is tried with mineral water, the deviation of the needle is considerable. 3. When the same mineral water is examined at various periods subsequent to the date at which it was drawn from its source, and at different temperatures, it is found that the higher the temperature is the greater is the electric mani-

festation, a result which is due to the greater amount of chemical change which takes place during high degrees of temperature. From the conclusions, it will be observed that M. Scoutetten believes rather in an electric than a chemico-physiological action of these waters. In some minor experiments he discovered that even the partial immersion of the body in a mineral bath produces an amount of electrical excitation, which occasionally extends so far as to produce feverish symptoms.

EFFECTS OF TOBACCO ON HEALTH.

M. Jolly has presented a paper to the French Academy of Medicine, in which he takes the opposite ground from that of Dr. B. W. Richardson (see "Annual of Scientific Discovery" for 1865, page 229). Starting from the fact that there has been of late years an enormous increase of smoking in France, and stating that sixteen pounds of tobacco, equivalent to fifty or sixty grammes of nicotine, are annually consumed by each smoker, he says that "statistics show that in exact relation with this increased consumption of tobacco is the increase of diseases of the nervous centres (insanity, general paralysis, paraplegia, ramollissement) and certain cancerous affections. Now, although Orientals, Turks, Greeks, Brazilians, and Hungarians, smoke to an excessive extent, they do so with almost impunity, from the fact that the indigenous tobacco which they use contains very slight proportions of nicotine, and sometimes none at all; while other nations, such as the English, the Swiss, French, Americans, etc., suffer much more severely. Up to the present time, no case of general or progressive paralysis has been discovered in any of the numerous localities of the East, where tobacco of so eminently mild a character, or some succedaneum, is employed. M. Moreau, in a careful investigation which he has made in the hospitals of Constantinople, Smyrna, Malta, and all the Mediterranean islands, has not been able to detect a single case of this kind. 'The cause,' he remarks, 'is plain enough, and eminently physiological. In all the regions of the Levant they do not intoxicate themselves with nicotine or alcohol, or the ambition of fortune or glory, but saturate themselves with opium and perfumes, sleeping away their time in torpor, indolence, and sensuality. They narcotize, but do not nicotinize themselves; and if opium, as has been said, is the poison of the intellect of the East, tobacco may one day prove in the West the poison of life itself.'"

M. Melsens has found, upon the average, a proportion of seven-tenths per cent. of nicotine held in suspension by tobacco smoke. The mischievousness of such an atmosphere is dwelt upon by M. Jolly, who also holds that general or progressive paralysis — a disease scarcely met with thirty years ago — is making rapid advance under the increased abuse of alcohol and tobacco. Insanity and affections of the nervous centres have enormously increased in France, and this increase is found to be, in men, almost entirely made up of cases of progressive paralysis (now forming more than sixty per cent. of the total cases); and whenever, in the asylums,

the history of such cases has been investigated, their dependence on the abuse of tobacco has been rendered obvious. In contrast with this is the rarity with which this form of the disease is met with in female lunatics. Among these paralytic lunatics, soldiers and sailors, who so much abuse tobacco, are found occupying the first rank. M. Jolly's investigations have led him to the conclusion that this abuse of tobacco is far more operative in the induction of this paralysis than alcohol or absinthe.

CAUSE OF INTERMITTENT AND REMITTENT FEVER.

Prof. J. H. Salisbury communicates to the "American Journal of Medical Sciences" an elaborate article, giving an account of numerous observations and investigations regarding the origin and cause of intermittent fever. Dr. Salisbury found, on microscopical examination of the salivary secretion and expectoration of those laboring under intermittent fever, and who resided upon ague levels, and were exposed to the evening, night, and morning exhalations and vapors arising from stagnant pools, swamps, and humid low grounds, that there occurred in these secretions a great variety of zoösporoid cells, animalcular bodies, diatoms, desmidiæ, algoid cells and filaments, and fungoid spores. Constantly and uniformly found in all cases, and usually in great abundance, were minute oblong cells, either single or aggregated, consisting of a distinct nucleus, surrounded by a smooth cell-wall, with a highly clear, apparently empty space between the outside cell-wall and the nucleus. They were not fungoid, but cells of an algoid type, resembling strongly those of the palmellæ. In persons residing above the summit plane of ague, these bodies were invariably absent.

By a series of carefully conducted experiments and observations the following facts were ascertained: —

1. That cryptogamic spores and other minute bodies are mainly elevated above the surface during the night. That they rise and are suspended in the cold, damp exhalations from the soil, after the sun has set, and fall again to the earth soon after the sun rises.
2. That in the latitude of Ohio, these bodies seldom rise above from thirty-five to sixty feet above the low levels. In the northern and central portions of the State, they rise from thirty-five to forty-five feet; in the southern, from forty to sixty feet.
3. That at Nashville and Memphis they rise from sixty to one hundred feet and more above the surface.
4. That above the summit-plane of the cool night exhalations, these bodies do not rise, and intermittents do not extend.
5. That the day air of malarial districts is quite free from these palmelloid spores, and from causes that produce intermittents.

Palmellæ belong to the lowest known vegetable organisms. The several forms of this type, which are constantly attendant on intermittent malarial disease, have received the generic name gemiasma (earth miasm), of which Dr. Salisbury enumerates six species.

In another series of extended observations, the local effects produced in the mouth and air-passages by inhaling these cells are

minutely described. They cause a dry, feverish, constricted feeling in the mouth, fauces, and throat, increasing until the fauces become parched and feverish, normal mucous discharges become checked, and the feeling soon extends to the bronchial and pulmonary surfaces, which also become dry, feverish, and constricted, with a heavy, congested sensation and dull pain. These peculiar symptoms generally last several hours after leaving the bog.

The author has made experiments relative to the production of intermittent fever in localities entirely free from malarial influence, by carrying boxes filled with surface earth from a malarious drying prairie bog, covered with the palmellæ, to these localities, and exposing persons to their emanations. Attacks of intermittent were the result.

The investigations of Dr. Salisbury must be considered highly important, as they seem to establish positively the *fons et origo* of malarious fever.

Dr. E. Holden of Newark, N. J., late of the U. S. N., communicates a paper to the same journal, entitled, "An Inquiry into the Causes of Certain Diseases on Ships of War," in which he expresses his opinion that fever of an intermittent type is produced by the growth of mould on board ship, under the action of hydrosulphuric acid of the bilge.

ANÆSTHETIC AGENTS.

New and Ready Mode of Producing Anæsthesia.—Dr. B. W. Richardson has been for some years engaged in researches for the production of local anæsthesia. Snow maintained that all narcotics produce anæsthesia by the process of arresting oxidation. Dr. Richardson has come to the conclusion that arrest of oxidation means arrest of motion, and that anæsthesia, in truth, means the temporary death of a part, *i. e.*, inertia in the molecules of the part. This led him to the conclusion that Dr. Arnott's plan of using extreme cold was the first true step in the progress of discovery; and that if it could be made easier of application, and at the same time could be combined with the use of a narcotic fluid, an important advance in therapeutics would necessarily follow.

By a simple apparatus, which divides an ether jet into a very fine spray, he can produce local anæsthesia at any time, with a cold six degrees below zero. He can distribute this spray into any of the cavities of the body.

When the ether spray thus produced is directed upon the outer skin, the skin is rendered insensible within a minute; but the effects do not end here. So soon as the skin is divided, the ether begins to exert on the nervous filaments the double action of cold and of etherization; so that the narcotism can be extended deeply to any desired extent. Pure rectified ether used in this manner is entirely negative; it causes no irritation, and may be applied to a deep wound, without any danger. Its chief application is in the production of superficial local anæsthesia; and it is admirably adapted for a large class of minor operations, for which chloroform has been generally used. The ether must be pure.

Rhigolene. — Prof. H J. Bigelow, in a communication in the "Boston Medical and Surgical Journal," 1866, speaks of this agent as follows: "The above name is proposed as convenient to designate a petroleum naphtha, boiling at 70° Fahr., one of the most volatile liquids obtained by the distillation of petroleum, and which has been applied to the production of cold by evaporation. It is a hydro-carbon, wholly destitute of oxygen, and is the lightest of all known liquids, having a specific gravity of 0.625. It has been shown that petroleum, vaporized and carefully condensed at different temperatures, offers a regular series of products, which present more material differences than that of their degree of volatility; and that the present product is probably a combination of some of the known products of petroleum, with those volatile and gaseous ones not yet fully examined, and to which this fluid owes its great volatility. When it was learned here that Mr. Richardson of London had produced a useful anæsthesia, by freezing through the agency of ether vapor, reducing the temperature to 6° below zero, Fahr., it occurred to me that a very volatile product of petroleum might be more sure to congeal the tissues, besides being far less expensive than ether. Mr. Merrill having, at my request, manufactured a liquid of which the boiling point was 70° Fahr., it proved that the mercury was easily depressed by this agent to 19° below zero, and that the skin could be with certainty frozen hard in five or ten seconds. A lower temperature might doubtless be produced, were it not for the ice which surrounds the bulb of the thermometer. This result may be approximately effected by the common and familiar 'spray-producer,' the concentric tubes of Mr. Richardson not being absolutely necessary to congeal the tissues with the rhigolene, as in his experiments with common ether. Freezing by rhigolene is far more sure than by ether, as suggested by Mr. Richardson, inasmuch as common ether, boiling only at about 96° instead of 70°, often fails to produce an adequate degree of cold. The rhigolene is more convenient, and more easily controlled than the freezing mixtures hitherto employed. Being quick in its action, inexpensive, and comparatively odorless, it will supersede general or local anæsthesia by ether or chloroform for small operations, and in private houses." Both the liquid and the vapor of rhigolene are highly inflammable.

New Anæsthetics. — Two new substances, which bid fair to rival even chloroform, have lately been introduced as anæsthetics, by an English physician. At the meeting of the British Medical Association, Dr. Nunneley exhibited some bromide of ethyl, and chloride of elayl (olefiant gas), both of which for some time past he had used as anæsthetics. He stated that he had not lately performed any serious operation, either in private practice or at the Leeds General Infirmary, without the patient being made insensible by one or the other of these agents, each of which he believed to possess important advantages over chloroform. They were among the many analogous bodies experimented on by him, and favorably mentioned in an essay on anæsthesia, published by him in 1849. At that time the difficulty and cost of their prepa-

ration were too great to allow of their being commonly employed. This difficulty, however, has been overcome; and, should their use become general, they can be made at a cost not exceeding that of chloroform. They both act speedily, pleasantly, and well. The patient may be kept insensible for any length of time, while the most serious and painful operations were being conducted. No disagreeable symptoms had in any case resulted from their use.

Chimogene. — In experimenting with the highly volatile and gaseous products of distillation, Dr. P. H. Vanderweyde succeeded in producing a liquid boiling at any desired degree of temperature, say at 60°, 50°, 40°, or even at 30° Fahr., causing by its evaporation the most intense cold. He proposes, therefore, to call it *Chimogene* (cold generator).

The desired degree of its boiling point depends only on a slight modification in its preparation; in fact, it may be made so volatile, that it requires very strong bottles and careful stoppering to hold it, as by lifting the stopper it foams like champagne, boiling at the common temperature. Pouring it from the bottle in drops or in a small stream, it will be evaporated before reaching the floor.

PHYSIOLOGICAL SUMMARY.

On the Production of Sexes. — M. Coste has been led to doubt the truth of the hypothesis, propounded by M. Thury, which supposes that every egg passes, during the period of its maturation, through two successive, but continuous, phases, during each of which it has a different sexual character. If fecundated in the first half, it would be a female; if in the latter, a male. From experiments on fowls, the author shows that the sexes are produced indifferently from eggs taken at the beginning, middle, or end of the laying. With regard to rabbits, M. Coste finds the same irregular result; in fact, altogether a larger number of males were born at the commencement of maturation. M. Thury's law is, therefore, not applicable to such mammals or to birds. The author is continuing his experiments to determine whether it holds good even in the bovine mammals, which M. Thury made the subject of his investigation.

Cause of the Redness in Inflammation. — Drs. Estor and St. Pierre (*Memoires de la Sociëté de Biologie*, 1865) have made investigations on the pneumatology of the blood coursing though inflamed parts, as the foot of a dog seared with the actual artery. They estimated the amount of oxygen present by treating the blood with carbonic oxide, as recommended by Bernard, and obtained the following results: —

Experiment.	*Inflamed Side.* Amount of O. in 100 parts of (venous) blood.	*Sound Side.* Amount of O. in 100 parts of (venous) blood.
1.	6.01.	2.41.
2.	6.04.	2.40.
3.	4.74.	2.36.
4.	3.60.	2.40.
5.	4.80.	2.40.

They conclude from these and other experiments: —

1. That the venous blood returning from an inflamed part contains more oxygen than the blood of the sound side, the proportion being as 1 : 1.5 or 2.5.

2. That the venous blood of the inflamed side contains more carbonic acid; and

3. That it is to the excess of oxygen in the venous blood, rendering it of brighter tint, that the increased redness of an inflamed part is due.

Engrafted Tissues. — The experiments of M. Bert are of the highest interest, as they show that the tissues of one animal may not only be engrafted on those of another, but that after a time they become supplied with blood-vessels, etc. The following case, which has just been published, is very instructive: The tail of a full grown rat was removed from the body, and then inclosed in a glass tube, and maintained for seventy-two hours at a temperature of from + 7° to + 8° centigrade. It was afterwards deprived of portions of its skin, and introduced into the subcutaneous cellular tissue of another adult rat. Three months afterwards the second animal was killed, and coloring matter was injected into its aorta. This coloring substance absolutely penetrated the marrow of the engrafted vertebræ, thus showing that the tail had been supplied with vessels communicating with those of its host's body.

Iodine. — Iodine is almost entirely wanting in young sea-weed, and it has reached its maximum quantity when the plant is thrown off in drift. Fermented liquors and wines contain iodine, but milk is richer in that substance than wine. The proportion of iodine in milk is in the inverse ratio of the quantity yielded. Eggs also contain iodine; a fowl's egg weighing 50 grains contains more iodine than a quart of cow's milk.

Creasote and Ferment. — A letter of M. Béchamp to M. Dumas mentions that creasote appears to be the agent which most strongly opposes the development of organic ferments, but adds that it does not interfere with the life of ferments or animalcules when they are once developed.

Beating of the Heart. — In ascending into the air, the heart-beats increase 5 for the first 3,000 feet, 7 for the next 1,500 feet, 8 for the next 1500, and 5 for each 1500 feet of ascent after that. This is an average increase of one beat for each 100 yards of ascent.

Sixth Sense in Man. — Dr. Hughes Bennett, in a paper before the British Association (1865), announced that the tendency of modern physiology was to ascribe to man a sixth sense. If there be placed before a man two small cubes, the one of lead and the other of wood, both gilded so as to look exactly alike, and both of the same temperature, not one of the five senses could tell the man which is lead and which is wood. He could tell this only by lifting them; and this sense of weight was likely to be recognized as a sixth sense.

Iron in the Blood. — M. Pelouze finds that the blood of birds contains, per 10,000 parts by weight, from 3 to 4 parts of iron;

and that the blood of man, and the mammalia generally, contains from 5 to 6 parts of iron per 10,000 parts of blood.

Copper in the Animal Body. — Dr. G. L. Ulex, of Hamburg, has published the result of extensive researches, showing that copper is one of the most widely disseminated substances in nature. It had been long known that copper existed in the blood of mollusks and others of the lower animals; but Dr. Ulex found it in mammalia, birds, batrachians, reptiles, fishes, and articulates also; in man, the horse, the ox, the lynx, the common fowl, the teal, the tortoise, the lizard, the adder, the frog, the eel, the haddock, etc. He concludes that it is found in the bodies of all animals, and says: "As animals live, directly and indirectly, upon plants, it follows that it must occur in all plants; and as plants derive their mineral constituents either from the soil or from sea-water, copper must be generally diffused through both these media."

Mortality of Paris. — As far as can be judged from historical documents, the annual mortality in Paris at the commencement of the last century was 1 in 28; 50 years later, 1 in 30; in 1836, 1 in 36; in 1846, 1 in 37; in 1851, 1 in 38; in 1856, 1 in 39. These numbers apply to old Paris. In 1860, the time of annexation, the population was increased by the addition of an area less favorable for the health than the interior of Paris. Still, the proportion of deaths in 1861, with 1,696,141 inhabitants, was 1 in 39; in 1862 and 1863, it was 1 in 40.

This improvement in the public health may be attributed to the great works carried forward in the capital, — that is, the opening of avenues, improved supply of water and drainage, the supervision over crowded and unwholesome tenement houses, and the organization of hospitals; also to the general prosperity of the working classes, who take better care of themselves, dress more warmly, and eat more wholesome and abundant food.

The Sphygmograph. — This is an instrument invented by Dr. E. J. Marey, a Paris physician, for producing a self-written record of the swellings and contractions of the arteries, known as the pulse. The main features of the instrument are the following: A principal beam, of light construction, is fastened on the arm by carefully-padded straps; to this is attached a lever of nearly the length of the fore-arm; the shorter arm of this lever rests gently but firmly on the pulse; at each rise of the artery and subsequent fall, the motion is exactly imparted to the lever, and the end of the longer arm performs the same movements as does the shorter, but on a much larger scale. To the end of the longer arm is attached a fine-pointed pencil, in contact with which a smooth strip of paper is made to move by clockwork in a horizontal direction. The effect of this arrangement is that a straight line would be drawn on the piece of paper were it not for the rhythmic perpendicular movement caused by the pulse, which results in the production of an undulated line, the waves in which represent the separate expansions of the artery. It is evident that since the movement of the paper is invariably uniform, the variations in the pulse will be distinctly indicated by the height, length, and form of the waves; and accordingly we have a most accurate and

valuable means of comparing the pulse in various individuals and under various circumstances. Some interesting results have been obtained by studying the pulse of diseased persons, and the instrument has been found to exhibit phenomena in the pulse which it was quite impossible to detect by the fingers. The "sphygmogram" of a person afflicted with a certain disease of the heart, for example, is found to exhibit a series of undulations, the ascending line of which is very long and tremulous, and but slightly oblique, while the descending is abrupt and nearly perpendicular. From this description it will be seen that this promises to be a valuable assistance to medical men in reducing their observations to something like exactness. — *Quart. Journ. of Science, July*, 1866.

Myograph. — M. Marey has invented an instrument, on the plan of his sphygmograph, which he calles a myograph, and which makes a drawing to indicate the movements of muscular fibres in their contractions. A muscular shock imparts a wave motion to the fibres; if a shock is prolonged till the muscle is fatigued, the waves lose their amplitude, and finally become extinct. A slow succession of shocks is marked by long ascending lines, and short descending ones; a quick succession leads to equality in the ascending and descending lines; and when the shocks are too quick for healthy action, — more than thirty-two per second, — a tetanic condition supervenes, and a straight line replaces the waved line.

Stomatoscope. — This is an instrument invented by Prof. Burns, of Breslau. A platinum spiral wire (inclosed in a box-wood cup, to prevent the transmission of heat), brought to a red heat by the passage of an electric current from two of Middeldorps' elements, is placed in the mouth behind the teeth. The light reflected by a very small mirror is sufficiently intense to render the jaw transparent, so as to allow of the vessels proceeding to the roots of the teeth, the smallest specks of caries, etc., becoming visible. By reason of the transparency, even the labial coronary artery may, in some subjects, be seen at the level of the commissure, and its course followed. The instrument is therefore likely to form a useful means of exploration in dental affections.

Iridoscope. — A new instrument produced by M. Houdin, by the aid of which an individual is able to see all that is going on in his own eye. It is simply an opaque shell to cover the eye, pierced in the centre with a very small hole. On looking through steadfastly at the sky, or at any diffused light, the observer may watch the tears streaming over the globe, and note the dilatation and contraction of the iris, and even see the aqueous humor poured in when the eye is fatigued by a long observation. It is needless to say, that with the aid of this instrument, a man can easily find out for himself whether he has a cataract or not. If he has, he will only see a sort of veil covering the luminous disk, which is seen by a healthy eye. The instrument is simple and curious, and will no doubt excite attention in those who are anxious to know more of themselves. An "iridoscope" may be readily extemporized by making a hole in the bottom of a pillbox with a fine needle.

TRANSMUTATION OF SPECIES.

Prof. Huxley, in an address before the British Association, in 1866, makes the following statement in regard to the question of the transmutation of species, so ably defended by Mr. Darwin, and which now claims as its supporters, as one of Nature's agencies, at least, some of the most eminent zoölogists, botanists, and palæontologists of Europe and this country.

Much observation must be made, and much evidence accumulated, before we can see our way to a theory of transmutation of species. The only valid, though cardinal, objection to such a theory, is the want of evidence that a change of the kind inferred really takes place, and that so little proof of it is forthcoming, in spite of the attention which has, for many years, been anxiously directed to the subject. The nearly allied species tantalize us by a certain flexibility of type, and by their near approach to one another; but they seem rigidly to abstain from the boundary lines; and the variations that take place seem to have no special reference to an approximation to those lines, but rather to a certain power of accommodation to external circumstances, necessary for the preservation of the species. We find considerable varieties in the human species. We do not yet clearly know how to connect even these with one another, or with a common origin. Some of these are more, some less, allied to the monkey; but between the lowest of the human and the highest of the monkey, there is a gap, the width of which will be differently estimated by different persons, but so wide that there has never yet been any doubt to which side any specimen should be referred. Now, if the one has been transmuted from the other, how comes it that the series has been broken, and the connecting links ceased to exist? The conditions are still favorable to the existence of the man and to the existence of the monkey; why are they not still favorable to existence of the species that have connected the one with the other? We may wonder, not only that the traces of species in past time are not forthcoming, but that the species are not now living. Moreover, we do not know that any conceivable conditions, operating through any number of years, will bring the gorilla or chimpanzee one whit nearer to man, would give them a foot more capable of bearing the body erect, a brain more capable of conceiving ideas, or a larynx more capable of communicating them. He did not think that much direct assistance has been given, by the theory of natural selection based upon the struggle for existence, ably propounded and ably defended as it has been; it has dispersed some of the fallacies and false objections which beset the idea of transmutation of species, and has so placed the question in a fairer position for discussion; but it reminds us forcibly of some of the real difficulties and objections. Though artificial selection may do much to modify species, it is rather by producing varieties, than by drawing away very far from the original stock. To the former there seems no limit; but the latter is stopped by the increasing unproductiveness and unhealthiness of the individuals, by the susceptibility to

disease, and the tendency to revert to the original type. So that increasing departure requires greatly increasing care; and we do not know that any amount of care and time would be sufficient to produce what might fairly be called a new species. The bringing about any marked change, by Nature's selection, is shown to be very hard of proof, and has opposed to its probability the fact that the members of a species which are most unlike have the greatest tendency to pair, and are the most fertile; so that we have here, in addition to the ready reversion of modified breeds to the original stock, a law by which the growth or perpetuation of peculiarities is prevented, and a constancy given to the characters of the species. This law is more striking from its contrast with the bar that exists to the pairing of different species, and the infertility of hybrids. Within a given range, dissimilarity promotes fertility. Beyond that range, it is incompatible with it.

These, and other considerations, have always inclined him to the opinion that modifications of animal type, occurring in nature, are more likely to be the result of external influences operating upon successive generations, influencing their development, their growth, and their maturity, than of "natural selection" and the "struggle for existence."

The slight variability of animal types through long periods, the clear manner in which many of them are worked out from one another, and which increasing investigation seems to render more and more apparent, make the prospect of proving that they are educed from one another by any of the hitherto supposed processes grow more and more distant, and the feeling arises that there must be some other law at work which has escaped our detection.

Whatever be the law and forces which effect and regulate the evolution of species, they are probably of the same kind as those which are operating in the inorganic world. The orderly and definite manner in which forms and features and specific characters are given and preserved in one instance, may be assumed to be of the same nature as in the other; and we must probably refer the fixed animal and vegetable types to influences identical with, or similar to, those by which the forms are assigned to crystals, and the stratification is given to rocks, by which the geological epochs have been determined, and the boundaries of our planetary and solar systems have been set. One cannot but think that it may be within the power of man to work out and to comprehend, in some degree at least, the principles by which these breaks in the organic and inorganic worlds, constituting as they clearly do an important feature in the plan of creation, are brought about and regulated.

In connection with this subject may be mentioned a paper presented to the same Association by Mr. A. R. Wallace,

On Reversed Sexual Characters in a Butterfly, and their Interpretation on the Theory of Modifications and Adaptive Mimicry. — In this paper, the author, who is an independent originator of the theory advanced by Darwin, gave the result of some of his own and Mr. Bates's observations on the origin of species in Lepidoptera. The Heliconidæ, a group of butterflies with a powerful

odor, such as to cause birds to avoid eating them, were simulated by the females of another group, which had no smell, and might otherwise fall ready victims to birds. By their great resemblance to the obnoxions butterflies, the scentless females were enabled to escape pursuit and deposit their eggs. In different regions there were different species, thus imitating and being imitated. Mr. Wallace conceived that this case was a crucial test of the truth of the Darwinian doctrine. The females least like the Heliconidæ had always been more subject to destruction, and consequently by this process of natural selection the present state of very close resemblance had resulted.

Prof. Huxley cautioned Mr. Wallace against considering this as a decisive case. It was explained quite as completely by the teleological doctrine of the late Dr. Paley.

Mr. Herbert Spencer thought he could show that the case described by Mr. Wallace could not be satisfactorily explained by Dr. Paley's teaching. He understood Mr. Wallace that the imitation was not complete, and varied in different individuals. This incompleteness was not to be explained were we to assume that the one butterfly was made in imitation of the other by the Creator; but it was readily accounted for by the law of evolution.

THE DIFFICULTY OF TRACING ORIGINS.

Mr. Grove, President of the British Association, in his Inaugural Address, August 23, 1866, favored the theory of Darwin, while upholding the doctrine of continuity in the universe. He said:—

"There is nothing, as Prof. Huxley has remarked, like an extinct order of birds or mammals, only a few isolated instances. It may be said the ancient world possessed a larger proportion of fish and amphibia, and was more suited to their existence. I see no reason for believing this, at least to anything like the extent contended for; the fauna and flora now in course of being preserved for future ages would give the same idea to our successors. Crowded as Europe is with cattle, birds, insects, etc., how few are geologically preserved; while the muddy or sandy margins of the ocean, the estuaries and deltas are yearly accumulating numerous crustacea and mollusca, with some fishes and reptiles, for the study of future palæontologists. If this position be right, then, notwithstanding the immense number of preserved fossils, there must have lived an immeasurably larger number of unpreserved organic beings, so that the chance of filling up the missing links, except in occasional instances, is very slight. Yet, where circumstances have remained suitable for their preservation, many closely-connected species are preserved; in other words, while the intermediate types in certain cases are lost, in others they exist. The opponents of continuity lay all stress on the lost, and none on the existing links. But there is another difficulty in the way of tracing a given organism to its parent-form, which, from our conventional mode of tracing genealogies, is never looked upon in its proper light. Where are we to look for the

remote ancestor of a given form? Each of us, supposing none of our progenitors to have intermarried with relatives, would have had, at or about the period of the Norman conquest, upwards of a hundred million direct ancestors of that generation; and if we add the intermediate ancestors, double that number. As each individual has a male and female parent, we have only to multiply by two for each thirty years, the average duration of a generation, and it will give the above result. Let any one assume that one of his ancestors at the time of the Norman conquest was a Moor, another a Celt, and a third a Laplander, and that these three were preserved while all the others were lost, he would never recognize either of them as his ancestor; he would only have the one hundred millionth part of the blood of each of them, and, as far as they were concerned, there would be no perceptible sign of identity of race. But the problem is more complex than that which I have stated. At the time of the conquest there were hardly a hundred million people in Europe. It follows that a great number of the ancestors of the *propositus* must have intermarried with relations; and then the pedigree, going back to the time of the conquest, instead of being represented by diverging lines, would form a net-work so tangled that no skill could unravel it. The law of probabilities would indicate that any two people in the same country, taken at hazard, would not have many generations to go back before they would find a common ancestor, who probably, could they have seen him or her in the life, had no traceable resemblance to either of them. Thus two animals of a very different form, and of what would be termed very different species, might have a common geological ancestor, and yet the skill of no comparative anatomist could trace the descent. From the long-continued conventional habit of tracing pedigrees through the male ancestor, we forget, in talking of progenitors, that each individual has a mother as well as a father, and there is no reason to suppose that he has in him less of the blood of the one than of the other. The recent discoveries in palæontology show us that man existed on this planet at an epoch far anterior to that commonly assigned to him."

ORIGIN OF SPECIES IN INSECTS

The following are the conclusions of Dr. D. B. Walsh, in a paper on "Phytophagic Varieties and Species of Insects." This name is given to those otherwise identical insects which differ, as varieties or species, according to the species of plant they feed upon. Difference of food, even when the food-plant belongs to widely distinct botanical families, is accompanied by no difference whatever, either in the larva, pupa, or perfect state, in many species of insects. On the other hand, difference of food is in others accompanied by a marked difference in the color of silk-producing secretions, in the colors, markings, size, structural differences, and chemical properties of gall-producing secretions, in one or both sexes, and in all stages of growth. From the long catalogue of facts enumerated by the author, he says: "For my own part,

as, on the most careful consideration, I am unable to draw any definite line in the above series, and to say with certainty that here end the varieties and here begin the species, I am therefore irresistibly led to believe that the former gradually strengthen and become developed into the latter, and that the difference between them is merely one of mode and degree.—*Amer. Journ. of Science, Sept.*, 1865.

NATIVE AMERICAN RACES.

At the meeting of the Anthropological Society, April, 1866, Mr. W. Bollaert read a paper on the "Anthropology of the New World." The author, in embodying his experiences of the Red Man, noticed the erroneous statement which had been made, that the physical configuration of American natives was the same all over the continent. This was not quite the case, even as regards color; while as to form, feature, physical and mental development, there are marked differences and peculiarities, resulting from causes investigated in detail. He gave minute descriptions of the various theories which had been propounded to account for the population of America, especially of the known facts regarding the colonization of the northern parts by the Icelanders in the tenth century. He condemned the theory which Rivero and Tschudi had advocated, that such originators of American theocracies as Quetzalcoatl of Mexico, Bochica of Bogotá, and Manco Capac of Peru, were Buddhist priests. His own researches on this subject were not confirmatory of this hypothesis. The native traditions of the aborigines were not confirmatory of this theory of Monogeny. He gave a minute description of the materials he had been able to collect concerning the Red Man, before and after the discovery of America by Columbus, adopting as examples the inhabitants of the Russian possessions in America, British North America, Newfoundland, the United States, West Indies, Texas, Mexico, Central America, New Granada, Quito, Brazil, Chili, the Pampas, and Peru.

The native population of America at the period of its discovery was estimated as over 100,000,000; at present there may be from 10 to 11,000,000. They are said to have some 400 languages, and 2,000 dialects. He considered the time required for the evolution of each of these to have been vast. He commented on the evidence which had been afforded of ancient human remains at Guadaloupe, in the West Indies (probably recent), the Florida coral reef, Natchez on the Mississippi, and the Brazilian bone-caves. Pottery had been found in Ecuador, under circumstances which showed that it had been submerged for an unknown time under the sea, and again upheaved. He pointed out some important differences between the physiological characters of the White and Red Man, and concluded by affirming that his inquiries into the subject of species and varieties led him to abandon the unity or monogenistic view, for the plurality or polygenistic theory of separate creations.

ZOÖLOGY OF BRAZIL.

The following information concerning the animals of Brazil is condensed from the lectures of Prof. Agassiz before the Lowell Institute, Boston, Mass., in October, 1866.

Fishes of the Amazon. — He alluded to the astonishing variety of fishes found in the Amazon, very far surpassing what was before known on the subject, and most astonishing in comparison with other rivers. The Mississippi had yielded but one hundred varieties, and the rivers of the old world not so many, though of larger size. He is reported to have collected over eighteen hundred varieties in the Amazon. The Amazon contained no cyprinidæ or suckers, no perch, no pickerel, no trout; but goniodonts teemed in its waters, in many species. The kinds varied in the different places in the valley, no two localities yielding the same kind. They were also found in other rivers in Brazil, and even north of that country in South America. They were to be found in the mud and in hollow trees in the water. One of the species took care of its young as no other fish did, being provided with apron-like appendages on the jaws, which extended along half the length of the abdomen. On these they deposit their eggs, and carry them about until the young are hatched. Another kind bored holes in the river bank, three or four feet in depth, and deposited their eggs therein in round bunches.

The family of *Callichthys*, characterized by two rows of scales upon their sides, with a depression between them, have the peculiar habit of leaving the water at times, and he said he had frequently found them on dry land three miles from the water. They deposit their eggs in a cavity, after the manner of the stickleback, and hatch them by sitting upon them. They will ascend trees.

The *Dorades* are mainly distinguished by a single row of scales on each side, though some of the genera have two and three rows. Another family, the *Aspherides*, lay their eggs and then pass over them, the eggs becoming agglutinated to the under sides of their bodies, and remaining held there by a filament until hatched.

He described several other families of this order, with their peculiarities of form, color, and habits, remarking that several of these families have hitherto been unknown to naturalists. The *Characines* represent in the tropic waters our salmon. The peculiar construction of the mouth marks the different families of this order, some of them being entirely toothless, others having teeth only in the upper jaw, and others having both jaws armed with teeth. These families also differ so much in color that the combination of lines seems almost endless, though there is a general plan in the colors as much as in the form. One of these families is a most formidable fish, having a wide mouth, armed on both sides with pointed, serrated teeth. A horse or cow falling into the river would be devoured in one hour by these greedy fish.

He had a curiosity to ascertain how the marine scates compared with the scates found in the rivers, and had made comparisons as he proceeded up the Para river. The first scate he found after

entering fresh water belonged to no marine genus ever found in the sea, and the next six or seven which he obtained exhibited the same dissimilarity. This was a fact against the theory of migration. It was a general fact, that, within a certain circumscribed area each fresh water tract has its distinct species; and it was remarkable how certain families, or even genera, prevail over others. In comparing the fishes of the northern and southern rivers of Brazil, the difference was found to be still greater, each basin having its special distribution.

He drew one general inference from these general statements, namely, that all these fishes are in their natural home, and have not migrated, but have originated where they are found.

Brazilian Reptiles. — Though serpents of great size, power, and virulence, abounded in Brazil, he said he had met with but few; and there was not much danger to travellers, who could penetrate the woods, or recline among the vegetation with impunity. If serpents were met, it was only as an accident to which men are liable everywhere.

Though there are many frogs and toads, there are no salamanders in Brazil. The tree-toad rivalled in beauty the brilliant plumage of some of the native birds. Then there were barking and crying frogs, whose voices might be mistaken for sounds uttered by large animals or by human beings. There were many varieties of reptiles; and the same localization prevailed as among fishes. This also prevailed among insects.

There were in the rivers, he said, a great abundance of turtles, congregating in some localities in masses of hundreds of thousands, all endeavoring to get on shore to lay their eggs, of which each turtle deposits from eighty to one hundred. There were also terrestrial tortoises. The alligators differed from the crocodiles of the old world in the arrangement of their teeth, and in other respects; and the lizards, which were numerous, were chiefly tree-lizards.

Birds and Mammals. — Of the varieties of the aquatic class of birds found in northern regions, he remarked, there are but few representatives in the Amazonian region. There are of the swimming birds, some ducks, and a variety of small geese, several species of the latter being unknown at the north. Of the wading birds, there are none resembling our plovers or sandpeeps; but the red ibis abounds in such numbers as to obscure the air, and the white herons and the large storks crowd the surfaces of the pools in the forest, or congregate along their margins. The birds allied to our gallinaceous fowls present a striking feature. One of these, called the unicorn, is as as large as a turkey, and has a horn-like appendage upon its head. There the gallinaceous birds proper do not resemble those of our own country, or of the countries of the East, their characteristic being a heavy build.

One of the glories of South America, he said, was the family of humming-birds. They are found not only in low lands, but in all the valleys of the Andes, in hundreds of varieties.

He observed that, as with other animals, whatever variety of birds was noted, it was seen that they were specially circum-

scribed in their localization. Their powers of locomotion, instead of facilitating their distribution over a wide surface, only seemed to allow them to remain in a genial clime. With reference to the mammalia, the localization of the different species was still more striking. He described several families of aquatic mammalia found in Brazil, both cetaceous and pachydermatous — the tapir and the peccary being the only genera of the latter. The existence of the fossil remains of mammalia, both in Brazil and in the United States, was next spoken of at some length, and the importance of the study of these remains, in determining the origin and distribution of animals, was alluded to. There were evidences, the lecturer said, that the rhinoceros, the elephant, and the megatherium, once had representatives in this country; and a Dutch naturalist had discovered a larger number of extinct species of animals in Brazil than now exist there of living species.

He next passed to the families of rodents, ruminants, and carnivorous animals, in all of which was manifested the same dissimilarity to the families existing at the north, and a similar peculiar circumscription of types. In the tropical regions, the only rodents which approach ours in appearance are the squirrels, and these are few in number. In the family of ruminants there are no bulls, cows, sheep, or antelopes. Even the deer, so numerous in North America, Europe, and Asia, are in Brazil reduced to a few small species, not exceeding the size of the common goat. The whole host of fur animals, characterizing northern regions, are wanting, and they are replaced by many varieties of skunks.

CLASSIFICATION OF MOLLUSCA.

In the proceedings of theEssex Institute, Salem, Mass., vol. iv., p. 162, is an article by Edward S. Morse on "A Classification of Mollusca, based on the Principle of Cephalization." He adopts the name "Saccata," proposed by Mr. Hyatt, as more fully expressing the type of the division than the term "Mollusca;" this name not only expressing the plan, but being equivalent to the titles Vertebrata, Articulata, and Radiata, and being in no way a qualitative appellation. The gradual morphological changes of the contents of the sac, and all other relations, are based on the principle of cephalization. "According to this principle, cephalic power is manifested either as a mechanical, sensorial, or psychical force. Thus the Cephalopods possess, in the greatest measure, all three; while Gasteropods, not indicating, to any great extent, aggressive action, may be said to manifest but little psychical power; and the Lamellibranchiates manifest essentially only mechanical action. We have cephalic power manifested in the mechanical action of the foot, thus: —

"1. Lamellibranchs — locomotion.

"2. Gasteropods — locomotion, prehension.

"3. Cephalopods — locomotion, prehension, and aggression.

"The characters may thus be stated: —

"*Saccata.* — 1. Animals of varied forms, without a radiate structure and without articulations.

"2. Stomach and viscera enclosed by a fleshy sac, which may be closed or open, at either one or both ends.

"3. Principal nerve masses consisting of ganglia, which are adjacent to or surround the œsophagus.

"4. Intestine bending inward, or having an outward flexure.

"5. Heart on the outer bend of intestine.

"SACCATA.	Holozoic, or Typic. Mouth opens anteriorly.	Sac open at anterior end.	Cephalopoda. Gasteropoda.
		Sac open at both ends.	Lamellibranchiata.
	Phytozoic or Hemitypic. Mouth opens posteriorly.	Sac open at posterior end.	Tunicata.
		Sac closed.	Brachiopoda. Polyzoa."

The paper is also published entire in the "American Journal of Science" for *July*, 1866.

SILK-PRODUCING SPIDER.

Dr. Burt G. Wilbur has brought to the notice of the scientific world a silk-producing spider, *Nephila plumipes*, which he believes may become useful in the arts as a source of silk. Those interested in the discovery and habits of this spider will find full details in the "Atlantic Monthly," and in the publications of the American Association for the Advancement of Science, Boston Society of Natural History, and American Academy of Arts and Sciences. He described the formation of the very large web at the meeting of the American Association. In the first place, the Nephila erects her scaffolding, afterwards consumed, and running about on that she stretches out her radii, converging to a point four times as near the top of the web as the bottom. Instead of wasting time by trying to work round and round like the common spider, impossible to do with the functional centre of her web where she places it, she goes back and forth drawing up each thread at the point where she attaches it to the radius with a sort of loop, which inclines it a little toward the centre. This web is perfectly dry and inelastic, — would never catch a fly. She begins again where the work stopped, and covers the whole web with a viscid and elastic gum, which arranges itself in drops, according to the attraction of cohesion, along the web. She will not spin a vertical web, but insists on an angle of seventy degrees, and hangs at the functional centre, on the under side of the web. Although her vignette shows eight eyes, Dr. Wilder is confident the Nephila is blind to objects, and can only distinguish light from darkness. When a fly is entangled, the spider goes out on a radius to devour it; but if off her radius she cannot see it, and returns to the centre to shake the web and ascertain from the vibration where its weight drags. He has seen two of these enormous spiders approach each other, entirely unconscious of each other's presence till their legs interlocked without touching. If they touched, ever so slightly, both would turn and run away. The

male is to the female in weight as 1 to 125, sometimes as 1 to 150. He seems to have only a generative function, and she carries him about on her shoulder. They change their skin strangely; the hard head and thorax divide evenly across the front; the soft body is dragged out through two wounds which one might say were across the shoulders. For some days it eats voraciously and becomes sluggish. The top of the head snaps up; the head shows and enlarges; it splits across the shoulders; the abdomen is dragged through; the old skin is off, but it still holds the jaws, palpi, and legs. This happens slowly at first, but he had had spiders pull their own legs off. They hang thirty minutes to harden their membranes.

MICROSCOPIC LIFE.

Shall we consider the universe more wonderful from its vastness, or its array of the minute? Shall we consider the far-off orb, whose light is thousands of years in traversing the space which separates it from our vision, a more impressive phenomenon than the monad, five hundred millions of which may exist in a drop of water? Shall we consider the revelations of the telescope of the immeasurably great, more glorious evidence of the divine order, than those of the microscope of the immeasurably little? The terms great and small, in this world we inhabit, are indeed relative, and we grievously err in considering that positively little which seems so to our relative forms of perception.

Under the highest magnifying powers of the microscope we still perceive organized beings possessed of life. We find them everywhere, in our bodies, our food, our water, our flowers, in our gardens, in the air we breathe, in snow and in ice. "In vain," says Bory St. Vincent, "has matter been considered as eminently brute, without life. Many observations prove that if it is not all active by its very nature, a part of it is essentially so, and the presence of this, operating according to certain laws, is able to produce life in an agglomeration of the molecules; and since these laws will always be imperfectly known, it will, at least, be rash to maintain that an infinite intelligence did not impose them, since they are manifested by their results."

Ehrenberg found a few species of infusoria in the subterranean water of mines; he met with several in some silver mines in Russia, at the depth of fifty-six fathoms below the surface; but he never detected them in atmospheric water, such as dew. He also discovered that the yellow dryfog — which has often been attributed to the tails of comets, and so alluded to by Humboldt and Arago — observed from time to time advancing from the Cape Verde islands towards the east, covering parts of North Africa, Italy, and Central Europe, is composed of myriads of silicious animalcula, carried away by the trade winds. Similar animalcula have been found in fixed or floating icebergs at twelve degrees north latitude, while numerous forms of the same group have been detected in hot mineral springs.

If a few flower-stalks or a handful of green leaves be placed in a glass of water, and allowed to remain there from two to four

days, exposed to the air and to the light, at the end of that time the water will have assumed a green, or brownish-green tinge, and, on being submitted to examination under the microscope, will be found to swarm with many descriptions of infusoria. How did they come there? Some say their eggs, or "buds," are constantly present in the air, driven about everywhere by the wind, and develop themselves whenever they happen to fall upon an appropriate medium, such as putrefying vegetable substances. Others say that the eggs form spontaneously in water containing vegetable matter, as the eggs of other animals in the womb.

Naturalists, such as Lamarck, Oken, Geoffroy St. Hilaire, Darwin, and others, consider infusoria (*Monads*) as the fundamental organic substance from which all higher organisms have been progressively developed. Nature created *Monads*, the most simple form of infusoria, from the gradual perfection of which, through myriads of centuries, and amidst all kinds of physical changes, all the higher classes of animals have been produced. On such points, while we may persistently investigate, we may reserve our judgment.

The *Monad*, the simplest form of infusorial life, consists of a fine pellucid membrane; it forms a very minute sphere or cell, having a few green or colored spots in its interior. It requires to be magnified 640 times to be seen at all. Some authors say it varies from 1-24,000 to 1-500th of an inch in size, according to the species. According to Humboldt, the true monad never exceeds 1-3,000th of a line in diameter. It effects its locomotion by means of cilia, fine hair-like processes which cover the whole surface of the body, and which are constantly vibrating.

Some of the infusorial animalcula secrete a covering of hard flint; so that the covering of infusoria is of two kinds: the one soft and apparently membranous; the other rigid and hard, having the appearance of a shell, though, from its flexibilty and transparent nature, it is more like horn. The microscopic beings belonging to the class of *Rhizopoda*—a class higher than infusoria—present also the latter peculiarity. This hard covering consists sometimes of silica, and sometimes of carbonate of lime. To it we owe the preservation of infusoria and foraminifera which have lain for centuries upon centuries in a fossil state, in the strata of the earth. It has been calculated that eight million individuals of *Monas crepusculum* can exist within the space that would be occupied by a grain of mustard-seed, the diameter of which does not exceed one-tenth of an inch. The rapid and mysterious transition of color which is observable in lakes, and which has often created alarm in the minds of the superstitious, has been attributed to infusoria. A lake of clear, transparent water will assume, for instance, a green color in the course of the day, it will become turbid or mud-colored about noon, when the sun brings the infusoria to the surface, rapidly develops them, and where they die by millions before night. Microscopic vegetables may produce similar results. Infusoria and rhizopoda play an important part in the phosphorescence of the sea. The luminosity of the waves is supposed to be entirely due to them.

Fossil infusoria have been detected in great numbers. They were first discovered in certain silicious deposits, near Berlin, but have been since recognized in all parts of the world. The silicious and imperishable envelop, before alluded to, enables them to be minutely investigated. These shell-like integuments, visible only under the microscope, constitute masses of white powder, known as mountain meal (*berg mehl*, German; *farine de montagne*, French). In Swedish Lapland, under a bed of decayed moss, is found an immense stratum of this substance. These fossil infusoria do not of themselves constitute an aliment of sufficient nutriment to sustain life; but in China, where "mountain meal" abounds in some districts, it is made use of to mix with other food. Infusorial earth has been found in America at West Point, and in different localities in New England. Some of the deposits are fifteen feet in thickness. Richmond, Virginia, reposes on a bed composed almost entirely of such earth.

The city of Berlin is built upon such a deposit, consisting of microscopic animals and plants, some of which are still living and propagate daily with great rapidity. Their existence is doubtless maintained by the waters of the Spree, situated on a higher level, and which filter through the deposit. It is feared that a period will arrive when a portion of the town will fall in, on account of the rapid development of these creatures, some of which, according to Ehrenberg, form in the space of four days no less than two cubic feet of new movable earth.

The polished slate of Bilin in Prussia, which is used for polishing metals, glass, marble, etc., is entirely composed of the silicious shells of infusoria and other animalcula, and forms a stratum fourteen feet thick. One cubic inch of this polished earth has been shown by accurate measurement and calculation, to contain forty-one millions individuals of *gallionella distans*, and 1,750,000,000 of *gallionella ferruginea*.

The material chalk appears to owe its origin in great part to remains of myriads of animalcula, principally *foraminifera*. They secrete a calcareous shell or covering, similar to that of the silicious infusoria.

The calcareous bed of the tertiary formation, known as nummulite limestone, is an interesting study, on account of the enormous quantity of nummulite shells — larger foraminifera — which it contains. This limestone can be traced from the Pyrenees, through the Alps and Apennines, into Asia Minor, and further, through northern Africa and Egypt, into Arabia, Persia, and northern India. A similar deposit occurs in the Paris tertiary basin, and in that of Brussels. The fine-grained and easily worked limestone, which affords such an excellent material for the decorated buildings of the French capital, is almost entirely formed of accumulated masses of the minute shells of foraminiferous animalcula. In this nummulite limestone, the matrix in which the nummulites are imbedded, is itself composed of the more minute foraminifera, and of the broken and cemented fragments of the larger pieces. — *Druggists' Circular.* 1866.

ZOÖLOGICAL SUMMARY.

Vitality of the Salmonidæ.—Mr. Miller has given the following important results from his own experiments on the circulation in young Salmonidæ, such as the European salmon, trout, grayling, and coregonus. In the earlier state, the vitality of the Salmonidæ has as its inferior limit—2° C., and as the higher + 30° C. With trout, and with the Salmonidæ in general, the necessities of respiration increase with the temperature. Water in which the fish live should be much more aerated, or more frequently renewed, when the temperature is above + 15° C., than when it remains below + 10° C. The transportation of embryonic eggs, and of young Salmonidæ, requires much less air, or less water, at a low temperature, than at a high temperature. The fertilized eggs will bear long journeys, and may be carried great distances, if kept moist at a temperature a little above zero. The most favorable temperature for the development of the young Salmonidæ is between 10° and 15° C.—*Amer. Journal of Science, vol.* 41, 1866.

Functions of the Air Cells in Birds.—Dr. Drosier read a paper, in 1866, before the Cambridge Philosophical Society, in which he maintained that the air-chambers in birds are not employed to lessen the specific gravity of the body. The floating power of the air in the sacs and bones of the bird, when raised to the average temperature of the bird's body, he calculated to be in a pigeon less than a grain; therefore he maintained that the bird was supported in the air solely by the muscular effort exerted in the downward stroke of the wing. Nor are the air cells designed for aerating the blood, because the vessels in them are very fine, and sparsely scattered. He considered their true functions to be, that, since the thoracic cells expand when the abdominal contract, and *vice versa*, during the expansion and contraction of the chest, a constant current of air is kept up through the lungs, and so fresh air plays constantly over the capillaries in the lungs, which are naked.

Parturition in the Kangaroo.—M. Alix claims for M. Jules Verreaux the discovery of the mode of parturition in the kangaroo. M. Verreaux kept a large number of these animals in captivity, and by attentive care day and night he was able to ascertain the following facts. When the female feels that she is about to expel an embryo, she applies her anterior paws to each side of the vulva, so as to open its lips; then she introduces her muzzle, and receives the embryo into the buccal cavity. The aperture of the marsupial pouch is then opened by the paws, and the embryo dropped into it from the mouth, when it soon attaches itself to the mammary gland. Both Owen and Bennett had guessed these facts, but M. Verreaux was the first to observe them.—*Quart. Journ. of Science*, 1866.

Incubation of Eggs in some of the Chromidæ.—In a letter from Prof. Agassiz, dated from Brazil, Sept. 22, 1865, he says: "I have observed a species of *Geophagus*, which I have described under the name of *G. Pedroinus*, the male of which carries on its snout

a very prominent knob, which is entirely wanting in the female and young. This same fish has a most extraordinary mode of reproduction. The eggs pass — I don't know how — into the mouth, the bottom of which they cover, between the internal appendages of the branchiæ, and especially in a pocket, formed by the superior pharyngians, which they completely fill. There they are hatched, and the young, free of their shell, continue to grow until they are in a fit state to take care of themselves. I don't know how long this takes, but I have already met with examples, in which the young were no longer provided with the vitelline sac."

Degrees of Domestication. — There are in animals three recognized and distinct degrees of capacity for domestication. The first class are animals of a "domesticated nature," being those which, when once thoroughly domesticated, continue habitually with man, will not willingly leave him, and, if they do so accidentally, will probably return; among these are cows, horses, sheep, and poultry. The second are animals capable of only an imperfect domestication. They breed freely in the homestead, and are useful to man; but, if they escape from him, will probably not return; among these are tamed deer, hawks and pheasants bred at home, and gold and silver fish in private waters. A third class, sometimes called domesticated, such as hares, rabbits, monkeys, parrots, canaries, etc., is altogether incapable of domestication; for, whatever an eccentric member of the species might do, they will, as a rule, escape to savage life at the first opportunity, unless coerced by climate or hunger. Some species require to be semi-domesticated for centuries, before they become completely so. Without attention to these distinctions, experiments in domestication are liable to be failures, or only partially successful.

Animality of Sponges. — Prof. H. J. Clark, in "Silliman's Journal" for November, 1866, communicates a paper on the animality of the ciliate sponges, which he regards as belonging to the Protozoa. He examines specially the marine species *Leucosolenia* (*Grantia*) *botryoides*, Bowerbank. He concludes as follows: "What are the diversities of other genera of the Spongiæ ciliatæ I cannot more than conjecture; but seeing that one of the genera is so closely related to the monociliate *Flagellata*, it can hardly be possible that the others are very far removed; and I shall feel warranted, therefore, in assuming, upon the premises, that the whole group of *Spongiæ ciliatæ* is as intimately allied with the monociliate Infusoria Flagellata as is possible for it to be without actually constituting, with the latter, a uniform family."

Temperature of Birds. — Dr. Davy has a paper on this subject in the "Proceedings Royal Society," No. 78. He thinks that the respiration of birds is less active than is commonly supposed, and that their high temperature is maintained by their warm clothing, and by the small loss of heat they experience through pulmonary or cutaneous evaporation.

Muscular Power of Insects. — M. Felix Plateau has made many experiments on the muscular force exerted by insects. By attaching a wire to the legs of insects, he ascertains the weight they

draw on a given surface, and finds that a beetle, *Donacia nymphea*, can pull 42.7 of its own weight. If a horse were equally powerful, he would be able to draw 25,000 kilogrammes, or more than double that number of pounds.

On the Pterodactyle.—Mr. Seely adduces reasons for supposing that the "Pterodactyle was a quadruped, and, when not flying, carried its wings folded up in front of the fore limbs." From a consideration of various points of structure, he concludes that the "Pterodactyle's place in nature appears to be side by side with the birds, between the reptiles and the mammals."

New Mammal from China.—A French missionary, M. Armand David, having sent home skins, etc., of the *mi-lou*, or *sseu-pou-siang*, a large sort of stag, M. Alph. Milne-Edwards describes it to the French Academy. The second Chinese name signifies "the four discordant characters," the creature resembling a stag in its horns, a cow in its feet, a camel in its neck, and an ass in its tail. The horns, which belong only to the male, are large and branched, but differ in some important particulars from the antlers of the stag. The fur is rough and gray, with a black line on the back and breast. The tail, instead of being short and thick, as is common with stags, is very long, and terminates in a tuft of long hair. The mi-lou is as big as a large stag. Herds of them live in an imperial park some distance from Pekin; but the Chinese do not know where they came from, or on what date they first arrived. M. David thinks that Huc and Gabet spoke of the mi-lou in describing "reindeer," which they saw beyond Koukou-noor, about lat. 36°. M. Milne-Edwards proposes to call the animal *Elaphurus Davidionis.*—*Intellectual Observer, July*, 1866.

Historic Age of the Dog.—M. Quatrefages states that in China the exact period of the introduction of the dog is known, viz., in the year B. C. 1122, about 3,000 years ago, or, about the period of the siege of Troy. The dog appears, from what he asserts, to be a domesticated jackal, and the jackal a savage dog.

Chinese Beauty's Foot.—On examination, no toe was visible but the big toe; the others had been doubled under the sole, with which they had become incorporated, and could not be distinguished from it except by the white seams and scars that deeply furrowed the skin. The instep was marked by the vestiges of large ulcers, consequent on the violence used to bend it into a lump, and in form, as well as in color, was like a dumpling; the limb from the foot to the knee was withered and flaccid as that of one long paralyzed.—*Travels in Mantchou Tartary.*

Voices of Fish.—M. Dufossé summed up a memoir on this subject before the French Academy with these general conclusions: "Anatomy, physiology, and the history of the manners of animals all agree in demonstrating that nature has been far from refusing to all fishes the gift of expressing by sounds their instinctive sensations; but she has not accorded to these beings that unity of mechanism in the formation of sonorous vibrations which she has done in the first three classes of the vertebrates. There are in the organization of fishes at least three essentially distinct mechanisms, of gradually diminishing physiological value. Many

species have the power of emitting commensurable sounds, musical, and engendered by a mechanism of which muscular vibration is the principal motive-power; others can give birth to breathing sounds like those which many reptiles emit; and finally others have only the power of making stridulent noises, the effect of a coarse mechanism, such as is found in a great number of insects. It would be a misconception of the physiological definition of the word voice, to use that word for the purpose of designating sounds so very different one from another; and especially the commensurable sounds which fishes produce by means of three organic mechanisms which have no resemblance to each other."

Vision of Fish and Amphibia.—M. Plateau, of Ghent, has recently published a sketch of his researches on this subject. His investigations were only extended to fresh-water fish, owing to the difficulty of procuring others in a fresh state. He finds that the cornea is flattened in the centre, but that a curvature is very apparent at the border. The crystalline lens is always spherical, and the liquid which fills the cavity of the eye is of the same, or nearly the same specific gravity as water. For purposes of comparison he has examined the eyes of aquatic birds, and of frogs, and of some aquatic mammalia, and he finds that in all the cornea is sensibly flattened in the centre, and the crystalline lens approaches the form of a sphere. In order to show that in the fish vision is as distinct in air as in water, and that this distinction is independent of any power of accomodation, he prepared a recently removed eye in such a manner as to show the formation of the image of external objects. He found that the distances of distinct vision were sensibly the same, whether the organ was in air or immersed in water. These experiments were made upon the eyes of two or three kinds of fresh-water fish and frogs. He did not extend them to the eyes of aquatic birds and mammals, but instances the similarity of structure with the eyes of fish as a proof that the same principle prevails in both cases. The paper was presented to the Belgian Academy.

The Polynesians and their Migrations.—M. Quatrefages has just published a book on this subject. His conclusions are these: "The Polynesians were not created on the spot, nor are they the last remains of pre-existing populations. Voluntary migrations have brought them into the archipelago of Oceanica. From their type, we may gather their origin; it is to be found in the Asiatic archipelago. In some of these migrations, they would fall in with some families of the black race, who might have been cast away on the same islands by the chances of the sea. He considers that none of these migrations are of a date anterior to the first Olympiad; and the great majority occurred about the commencement of our epoch."

Preservation of Zoölogical Specimens with their Natural Colors.—Mr. A. E. Verrill thus writes to "Silliman's Journal": "Star-fishes may be dried, so as to retain their natural colors almost unimpaired, by immersing them in alcohol of moderate strength for about a minute, or just long enough to destroy the life and

produce contraction of the tissues, and afterward drying them rapidly by artificial heat. The drying is best effected by placing them upon an open cloth stretched tightly upon a frame, and supported a few feet above a stove. Care should be taken not to raise the heat too high, as the green shades change to red at a temperature near that of boiling water. By this process I have succeeded in preserving the delicate shades of red, purple, and orange, of the species found on the coast of New England, specimens of which are in the Museum of Yale College. The same process is equally applicable to Echini and Crustacea."

Silk from Eggs of Fish. — A French savant has lately discovered that certain fish contain eggs enveloped in veritable silk cocoons. Each egg measures thirty-five centimetres long by thirteen broad, and weighs two hundred and forty grammes, and is covered with silky filaments, which may be employed in weaving.

The Little Folks of Africa. — The small people of Equatorial Africa, recently discovered by Du Chaillu, about 1° and 2° south latitude and 12° east longitude, are described as of migratory habits, and as changing their temporary shelter under trees from one place to another. While the inhabitants of this mountain region are lighter in color than those of the sea-shore, these Obongo are still less dark. They have only short tufts of hair upon their heads, and are thus strikingly distinguished from the settled inhabltants, who wear large turrets of hair upon their heads. "The following are the measurements I was enabled to make: The only adult male measured four feet and six inches, but as one of the women reached five feet and one quarter of an inch (she being extraordinarily tall), I have no doubt some of the men are equally tall, and some perhaps taller. The other women I measured had the following height: four feet one inch, four feet seven and one-quarter inches, four feet feet five inches, and the smallest, four feet and one-quarter of an inch."

PALÆONTOLOGICAL SUMMARY.

Gigantic Dinosaurian in the Cretaceous of New Jersey. — E. D. Cope exhibited the remains of a gigantic extinct Dinosaurian-from the cretaceous green sand of New Jersey, viz., portions of the under jaw with teeth, of the scapular arch, including supposed clavicles, two humeri, left femur, right tibia and fibula, numerous phalanges, lumbar, sacral, and caudal vertebræ, and numerous undetermined fragments. Remains were found about two miles south of Barnesboro,' Gloucester County, N. J. The bones were taken from about twenty feet below the surface in the top of the "chocolate" bed, which immediately underlies the green stratum, which is of such value as manure.

The discovery of this animal fills a hiatus in the cretaceous fauna, revealing the carnivorous enemy of the great herbivorous Hadrosaurus, as the Dinodon was related to the Trachodon of the Nebraska beds, and the Megalosaurus to the Iguanodon of the European Wealden and Oolite. In size this creature equalled the Megalosaurus, and with it and Dinodon constituted the most for-

midable type of rapacious terrestrial vertebrates of which we have any knowledge. In its dentition and huge prehensile claws it resembled closely Megalosaurus; but the femur, resembling in its proximal regions more nearly that of the Iguanodon, indicated the probable existence of other equally important differences, and its pertaining to another genus. He proposed the name of *Lælaps aquilunguis*. — *Proc. Acad. Nat. Sci., Philad.*, 1866.

Discovery of a Mastodon at Cohoes, N. Y. — During some recent excavations (September, 1866) made by the Harmony Mills Co., Cohoes (about one thousand feet below Cohoes Falls), a number of pot holes were discovered in an ancient bed of the Mohawk River, one of which contained the lower jaw of a mastodon imbedded in peat and drift wood. These pot holes are worn in the Hudson River shale, about a hundred feet above the present bed of the Mohawk, and about a mile from where it enters the Hudson. The one containing the remains was about two hundred and fifty feet from the south bank of the Mohawk. The jaw, which was in an excellent state of preservation, measured about twenty-eight inches in length and twenty-two in breadth between the condyles: on the right side there was one molar, and on the left two, one of which was four inches and the other six and one-half inches in length. A considerable portion of the skeleton has been found, in a good state of preservation, and evidently belongs to the common mastodon of North America. The imperfect ossification of the epiphyses shows that the animal was comparatively young, though a female. The pit in which the remains were found was about forty feet deep; the arrangement of the materials showed that they had been deposited rapidly, and a part of a beaver dam, found near the bottom, would indicate that the whole had been swept in by a freshet. No other animal remains were found except those already mentioned, although the "beaver sticks" probably indicate one contemporary of the mastodon.

Ichthyosaurian Skin. — A specimen of the *I. tenuirostris*, recently obtained at Barrow-on-Soar, shows a large extension of the dermal covering upon the surface of the slab, seeming to indicate that the animal had a prominent ridge along the dorsal region, similar in appearance to that which the males of the pond-newt (*Triton cristatus*) present in the spring.

New Fossil Reptile. — M. D'Archiac has recently described, before the French Academy of Sciences, a new fossil reptile found by M. Frossard in the bituminous schist near Autun, Saone et Loire. There were found with these remains some fish, coprolites, and plants, at a depth of two metres below a quaternary deposit, in a stratum five to six metres thick, two and a half of which are now worked for the manufacture of mineral oil. The new reptile belongs to Prof. Owen's Ganocephali, strange vertebrates, with ill-defined characters, apparently representing the embryo age of reptiles, just as the Ganoids, with incompletely ossified vertebræ, represent the embryo age of fishes. The new fossil has been called *Actinodon*.

Dinosaurian Reptile from the Stromberg Mountains, So. Africa. — Prof. T. H. Huxley exhibited the specimen to the Geological So-

ciety, in November, 1866. It is a portion of a right femur, twenty-five and a half inches long, so that the entire bone may be safely assumed to have exceeded thirty inches in length. The peculiar form of the bone, and the characters and position of the trochanters, leave no doubt of the Dinosaurian affinities of the reptile to which it belonged, which must have been comparable in point of size to its near allies, the Megalosaurus and the Iguanodon. To the former of these it possesses the closest affinity, but differs in the proportional size and form of its trochanters, and in its much heavier proportions; and the author proposes for it the name of *Euskelosaurus Brownii.*

Anthrakerpeton, a New Fossil Reptile.—Prof. Owen has described a new fossil reptile, under the above name, from the coal beds of Llantrissent, Glamorganshire, Wales, from the lower part of the "middle," if not from the upper of the "lower" coal measures. It is intermediate in size between Baphetes and Dendrerpeton; the ribs are longer than in any known Labyrinthodont, and with the bones of the limbs indicate that the animal belonged to that low air-breathing type which, with developmental condition of the bones like those in some fishes, and very common in Devonian, showed forms of the skeleton more like those in Saurian reptiles than in the modern air-breathing Batrachians.—*Reader, Jan.* 7, '65

New Dinosaurian.—A new dinosaurian has been found in the Wealden Formation, Isle of Wight, by Rev. W. Fox. The animal, for which Prof. Owen has proposed the name of *Polyacanthus*, was over 6 feet long from the shoulder to the rump, had a massive tail 5 feet long, legs about 4 feet long, and a broad short foot. It had a bony armor of plates ½ an inch to 4 inches broad and ½ inch thick, excepting along the back, over which there was a great bony shield; and along the sides of the body and tail there were spine-like bones, some of which are 15 inches long and weigh 7 pounds.

Archæopteryx.—On one of the two slabs from Solenhofen containing remains of the Archæopteryx, there is a "crescent shaped protuberance, which is pronounced by Mr. Evans to have been due to the remains of the *cranium* of the Archæopteryx, and even the form of the brain cavity and position of the brain,—both ornithic in character,—are supposed to be made out."

Quadruped Birds.—In a supplementary volume to Prof. Hitchcock's Work "On the Ichnology of the Connecticut Valley," further considerations are adduced in favor of the bird-like and quadrupedal character of the foot-marks. Reptilian birds and bird-like reptiles will probably be discovered, filling out the class *Saurornia*, lately proposed by Mr. Seely for the Pterodactyles. Evidence is now accumulating of many links between the reptile and the bird, already considered as most closely related. We have a bird with teeth, and a long tail and hooks on its wings in the *Archæopteryx;* we have a reptile with wings and probably plumage in the *Pterodactyle;* and now it appears, from the evidence of the Connecticut sandstones, that there existed strange four-footed birds, the wings probably provided with feet-like extremities, also possessing tails, and covered with feathers.

CLIMBING PLANTS. BY CHARLES DARWIN.

"Plants become climbers in order to reach the light, and expose a large surface of leaves to its action and that of the free air. Their advantage is, that they do it with wonderfully little expenditure of organized matter in comparison with trees, which have to support a heavy load of branches by a massive trunk. Of the different sorts of climbers, hook-climbers are the least efficient, at least in temperate climates, as they climb only in the midst of an entangled mass of vegetation. Next are root-climbers, which are admirably adapted to ascend naked faces of rock; but when they climb trees, they must keep much in the shade, and follow the trunk, for their rootlets can adhere only by long-continued and close contact with a steady surface. Third, spiral-twiners, with leaf-climbers and tendril-bearers, which agree in their power of spontaneously revolving and of grasping objects which they reach, are the most numerous in kinds, and most perfect in mechanism; they can easily pass from branch to branch, and securely ramble over a wide and sun-lit surface." . . . "Why have nearly all the plants in so many aboriginally twining groups been converted into leaf-climbers or tendril-bearers? Of what advantage could this have been to them? Why did they not remain simple twiners? We can see several reasons. It might be an advantage to a plant to acquire a thicker stem, with short internodes, bearing many or large leaves; and such stems are ill-fitted for twining. Any one who will look, during windy weather at twining plants, will see that they are easily blown from their support; not so with tendril-bearers or leaf-climbers, for they quickly and firmly grasp their support by a much more efficient kind of movement. . . . From possessing the power of movement or contact, a tendril can be made very long and thin; so that little organic matter is expended in their development, and yet a wide circle is swept."—*Journal of Linnæan Society*, 1866.

VEGETABLE PARASITES OF MAN.

At a recent meeting of the Quekett Microscopical Society, a paper was read by Dr. Tilbury Fox, on the "Vegetable Parasitism of Living Beings," of no little interest, as bearing upon the "blue mist" question raised by Mr. Glaisher. It has been suggested that the blue mist may be due to the presence in the atmosphere of the spores of low forms of vegetable life. Dr. Fox's paper embraced an account of the life and influence of minute fungi in general; showed that the presence of cell-structures was to be expected in all situations to which the air has access, their discovery hitherto having been delayed by the absence of observation and the want of a sufficiently high-powered microscope. They are especially prevalent at such seasons as the present, in which rusts and mildews have abounded. These germs are very light, and can be easily wafted by the air from place to place. They seem not only to be found in spots acces-

sible to the external air, but also deep in the tissues of living things, being carried inwards bodily by the growing tissues, in the same way that particles of charcoal get into the interior of the intestinal vessels running to the liver. In ordinary "ring-worm," the fungi which are the cause of the disease, according to Dr. Fox, get into the hair follicle, reach the root, and are carried up by the growing shaft into the body of the hair. In like way, rusts effect an entrance within the leaves of grown-up plants, but at a very early date, through the first cotyledonous leaves. We are led to suppose that the entrance of mildews and rusts is oftentimes at a very early date, and that the germs lie dormant, often for a long time, till the favorable opportunity arrives for their development. Fungi never appear to flourish on healthy surfaces, but always on those which belong to devitalized beings, and only constitute disease when they are developed to an excessive amount. The author entered into the question of the polymorphism of fungi, and the effects they produce in disease, showing that these are chemical, mechanical, and vital. After speaking especially of ring-worm, he concluded — and this is the interesting point in reference to the "blue mist" — that the prevalence in undue amount of microscopic fungi is always coincident with that of epidemic diseases; that the two could not be regarded as cause and effect, but were both helped out by the same influence. Whatever debilitates man renders him more liable to epidemic disease, and whatever induces an unhealthy state of vegetation favors the rapid development upon it of fungi such as constitute rusts, moulds, and mildews; but these do not seem to be capable of producing anything like epidemic poison, which is probably not vegetable in nature. The existence, then, of the "blue mist," supposing it to be due to vegetable germs, can only be looked upon as a coincidence as far as cholera is concerned. — *Reader*, 1866.

IN WHAT PARTS OF PLANTS THE POTASH RESIDES.

On this subject some curious chemico-agricultural inquiries have recently been reported to the French Academy by Mr. Isidore Pierre. The object of this savant's researches was to discover in what parts of cereal plants, and during what seasons, potash is most abundant. In carrying out his investigations, the greatest care was taken to insure the examination of the corresponding parts of several specimens of corn. The plants were analyzed before flowering, in bloom, and in the fruit-time. From a great number of experiments the author draws the following conclusions: 1. That in the various parts of the plant (leaves, nodes, and internodes), the proportion of potash increases in a well-marked manner as we pass from the lower to the upper parts. 2. That in parts of the same name and position this proportion tends to diminish as the plant advances towards the period of ripening. Sometimes this diminution is much less marked in the leaves than in the nodes and internodes. It seems that potash salts play a more important part in the life of plants than soda salts; in fact, it is seen that the former predominate in those parts, while soda is

generally found most abundant in the structures which are earliest developed, and whose office is rather temporary, or, at least, of secondary importance. From these facts, it will be seen that the adversaries of the employment of common salt as a manure have a new argument in their favor, so far as relates to the cultivation of corn. The nodes of cereals contain an enormous quantity of potash, more than 4.5 per cent. of their entire weight, and nearly half that of their ashes.

THE VINEGAR PLANT.

The term Vinegar Plant is applied to a tough, leathery formation, which under certain circumstances makes its appearance in saccharine solutions, undergoing the acetous fermentation. It is, no doubt, essentially the same plant as that which occurs in a less compact form in the French vinegar vats, and which encrusts the brush-twigs or shavings used in the German process.

Vinegar plants are frequently employed in domestic economy, for the manufacture of vinegar; and a well-grown specimen bears considerable resemblance to a piece of buckskin leather that has been soaked in water. If a young vinegar plant is placed in a vessel containing half a gallon of brown sugar and water, to which a little treacle may be added, and is kept in a dark, warm place, it grows rapidly, chiefly by accession to its lower surface, and it extends laterally until it reaches the sides of the vessel, the form of which it assumes. In a month or six weeks, the saccharine solution will be converted into strong, well-flavored vinegar. The plant is then removed, and the vinegar is boiled to kill the spores it contains.

At the close of this process of vinegar-making, the plant will be found to have increased greatly in thickness, and the under or newly-formed portions will be of a softer and looser texture than the upper layers. In this condition the plant is readily divided by horizontal splitting into two or more layers, one of which, if placed in a fresh solution, will soon excite the vinegar fermentation, and increase in bulk, while the acetic acid is being formed. —*Microscopic Quarterly*, April, 1865.

THE EUCALYPTUS.

The Eucalyptus of Australia, recently introduced into the "Jardin d'Acclimation" of Algiers, will become of much importance in the French colonies of Algiers.

In less than three years it has attained a height of ten "metres," whilst in Australia it often reaches that of one hundred and five "metres" and above, and its diameter, at one "metre" from the ground, is about seven "metres" and more. The boards made out of it are without any imperfection, and their length is of about sixty "metres." The wood, which is very hard, and of a density superior to that of oak, is worked with great facility when it is yet green. As it is of different shades, and will take a beautiful polish, it is of great use in cabinet-work.

The astringent gum, known by the name of "kina," is obtained by an incision in the bark of this tree. The flowers are white and balsamic, and are much liked by the bees. The Eucalyptus is tap-rooted; that is to say, its roots penetrate vertically into the ground. It is an evergreen, and the leaves resemble those of the laurel. When the tree has already the height of about forty "metres," the lateral branches develop themselves in a way which is really extraordinary. Some of them measure about thirty "metres" in length. Imagine a tree higher than one hundred "metres," the top of which has a circumference of nearly two hundred "metres," as large as the roof of a church. The seed of the Eucalyptus is very small, and looks like tobacco-seed. Its lateral branches are very numerous, and closely collected around the principal stem.

BOTANY OF BRAZIL.

The following facts are from notes taken of Prof. Agassiz's lectures before the Lowell Institute, Boston, Mass., in October, 1866, from his personal examination in Brazil: —

In speaking of the extraordinarily profuse vegetation of the valley of the Amazon, Professor Agassiz said it covered the whole surface of the land, and encroached upon the water. Indeed, the quantity of water plants is as remarkable as that of terrestrial plants. The density of the land vegetation is so great that the only means of traversing the country is by the water courses, and, when the traveller leaves these, he must cut his way with the axe; so that, however civilization may extend here, there can never be any extensive land communication, on account of the great expenditure which would be required for bridges.

Words cannot express the variety, beauty, and combinations of this vegetation. One of its most striking characteristics is its heterogeneity. There are not simply a few kinds found together, presenting sameness and monotony, as at the north. On the contrary, there are hardly ever two trees of the same kind, or two plants of the same species, found side by side. The trees do not stand alone, in open spaces, but are clothed and interlaced with vines, creepers, and parasites, hard to penetrate. This character of the vegetation extends over the whole basin. In the lakes the aquatic plants grow so thickly that the traveller, threading his way among them with a boat, sails for miles without seeing either water or earth.

He observed that the most prominent feature of the Amazonian vegetation is the presence of innumerable palms, in the form of trees, bushes, and creepers. We look in vain for pines, maples, oaks, willow, and other trees familiar to us in the United States. The aspect of vegetation, the character of the trees, and their combinations, change as we travel. Of the palms, one variety rises to the height of one hundred feet before sending out its leaves, which crown its top like a dome. Another variety sends out its leaves immediately from the root. The flowers and fruit of the palms also vary. Some of them bear nuts of peculiar form, others berries, and the fruit of some of them strongly resembles

peaches, cherries, and grapes. Each region produces its peculiar fruit. The leaves of some of the species were so large, that he had seen two men sitting in the axil of one of them. Some of these leaves measure thirty to forty feet in length, and ten to fifteen feet in width; and even when dry one of them was a heavy load for one man to drag.

In examining the ground of the diversity of the palms, he said he had found it to rest on the arrangement of the leaves. The result of the investigation of this arrangement was the discovery that the leaves occupy as much space as possible, and thereby get as much of the surrounding influences as it is possible for them to obtain. All palms might be divided into two groups, those having fan-shaped leaves, and those having pinnate or feather-shaped leaves. It had been his study to ascertain which of these was the lower and which the higher order. Observing that the leaves first germinating were fan-shaped, and that the youngest palms bore fan-shaped leaves, and considering that the younger palm is inferior to the adult, he had no doubt that the fan-leaved palms were the lower order, and were the first to appear upon the earth. This was an important fact to be known in the investigation of fossils, and in comparing the embryonic with the later conditions.

Passing to other families of plants, he said there were other representatives quite as abundant as the palms. One of the most surprising features of the vegetation were the innumerable orchidæ, growing as parasites upon other plants, twining around them, or hanging from them, in great variety of colors. Nearest akin to these were the various species of the banana family. Of plants allied to our own trees there were none. There was not a single representative of the catkin family, except a small willow growing in the mud-flats of the Amazon. Of the herbaceous plants found in our latitude, such as the ranunculus and the mustard-plant, there were no representatives. The pepper family had numerous representatives, some growing to stately trees. There were also numerous trees of the genus Laurus, such as sassafras, camphor, and cinnamon.

He called attention to a very peculiar feature of Brazilian vegetation, namely, the stately forms of plants which with us are but humble plants. These also have a marvellous diversity of foliage and beauty of flowers. The papilionaceous plants have a diversity of which our plants give us no idea. Another peculiar feature, is that plants widely differing from our own have uses similar to those of other families at the north, bearing fruits resembling nuts, peaches, and plums of northern growth. There is also an extraordinary diversity of timber and wood suitable for cabinet work, delicious fruits, and great wealth of medicinal plants and dyewoods.

BOTANICAL SUMMARY.

Sand Food-Plant of Sonora. — Dr. Torrey has described and figured in the eighth volume of the "Annals of the Lyceum of Natural History," New York, the *Ammobroma Sonoræ*, an extraor-

dinary root-parasitic plant, of the region at the head of the Gulf of California. It had been briefly noticed before as a new genus, allied to the rare Mexican *Corallophyllum* (Kunth), or *Lennoa* (Lexarza), and to the little-known Californian *Pholisma* (Nuttal). These strange plants, though justly regarded rather Monotropaceous than Orobanchaceous, are still obscure. Growing in a sandy desert, almost covered by the sand in which it lies, this plant was found by its discoverer, Col. A. B. Gray, to form a considerable part of the sustenance of the Papigos Indians. It is said to be very luscious when first gathered and cooked, resembling in taste the sweet potato, but far more delicate.

Absorption of Carbonic Acid by Plants. — M. Boussingault has recently made some experiments, reported in vol. lx., "Comptes Rendus," on the absorption and assimilation of carbonic acid by leaves exposed to sun-light. His results are as follows: 1. Leaves exposed to the sun in pure carbonic acid do not decompose this gas, or, if they do, it is with extreme slowness. 2. Leaves exposed in a mixture of carbonic acid and atmospheric air rapidly decompose the former gas; oxygen does not seem to interfere in the phenomenon. 3. Carbonic acid is rapidly decomposed by leaves when that gas is mixed with either hydrogen or nitrogen. The author has pointed out some analogies of these phenomena to the slow combustion of phosphorus under certain circumstances; thus, phosphorus placed in pure oxygen does not become luminous, and does not burn, or, if it does, burns with excessive slowness; in a mixture of oxygen and atmospheric air, it burns rapidly; it also burns when placed in oxygen mixed with hydrogen, nitrogen, or carbonic acid. Phosphorus, which does not burn in pure oxygen at an ordinary pressure, becomes combustible when the gas is rarefied; and M. Boussingault found that, similarly, a leaf placed in rarefied pure carbonic acid decomposed the gas and evolved oxygen. See also vol. lxi., "Comptes Rendus," for a continuation of his experiments.

The Gigantic Sequoia. — M. De Candolle, President of the London International Horticultural Exhibition, held in May, 1866, announced that a recent very exact measurement had been made of the diameter of the trunk of one of the gigantic Sequoias of California. The tree was the base of the "Old Maid," the stump of which now serves as a dancing floor; the measurement was made by Mr. De La Rue and his assistant, on a slip of paper stretched across the whole diameter of the section (26 feet 5 inches, at 6 feet from the ground), and the rings were carefully counted and marked on the slip, — on one semi-diameter 1,223, on the other 1245; the mean 1,234, — making the tree about 1,225 years old.

Rotting of Fruits. — M. C. Davaine has presented to the French Academy of Sciences a note on the "Rotting of Fruits," in which he states that the natural rotting of fruits is ordinarily due to the development of the microscopic fungi, *Mucor mucedo* and *Penicillum glaucum.* The thicker the epidermis of a fruit, the longer it will keep. The author points out the difference in the progress of the change under the influence of the two fungi; that produced by *Mucor* being much more rapid than that set up by *Penicillum.*

Temperature at which Plants Germinate. — According to Alph. De Candolle, in the "Proceedings of the Société Helvetique des Sci. Nat.," 1866, white mustard seed will germinate below 32° F.; *Trifolium repens* at a little above 42° F.; Indian corn at 48° F., but not below 42° F.; sesamum at 55.4° F.; melon seed at 63° F. Seeds will not germinate above certain temperatures, varying with their species and the amount of moisture present; thus the greater part of some *T. repens* seed did not germinate above 83° F. Thus, seeds only germinate between certain limits of temperature, and those which can only do so within narrow limits are least able to extend themselves geographically.

The Change of Leaves. — The cause of the beautiful tints which our foliage assumes during the autumnal months has long been a subject of investigation, and many are the hypotheses that have been put forth in explanation.

M. Frémy, who has devoted considerable attention to this subject, stated, as the result of a series of experiments, that he had succeeded in resolving the green coloring matter of the leaf (*chlorophyll*) into two components; one, a yellowish substance, he called *phylloxanthin*, the other, a blue matter, for which he proposed the name *phyllocyanin*. By considering the blue as more evanescent, the different shades of yellow leaves might be produced.

These views were very generally accepted, till recently Frémy has again appeared, essentially retracting his original views. He now gives, as the result of subsequent experiments, the new supposition that *chlorophyll* is a simple green coloring matter very unfixed, being influenced by vegetation, thus passing through varied modifications.

M. Carey Lea, of Philadelphia, has lately advanced a theory in which he considers light as the primary cause, producing photographic changes of color.

During the healthy state of the leaf, vitality counteracts this influence, but as the fall approaches the frost begins its work; the petioles dry up, the leaf gradually loses its firm hold upon the branch, then the action of light, no longer held in check by the vital principle, predominates, the leaf falls away, but in fading acquires those brilliant hues that variegate our forests. — *Scientific American.*

The Giant Radish of Java. — The *Raphanus caudatus*, the giant radish of Java, where it is known as Mougri, has been recently introduced into England, and is found to thrive extremely well in common gardens, the seeds germinating easily, and the plants producing a profusion of blossom in about eight weeks, the plant often making a growth of five or six inches in twenty-four hours. The root is not eaten, only the pods, which often attain a length of three feet. The plants should be tied upright, as they produce from fifteen to twenty pods each, growing in fantastic and irregular shapes. Eaten raw, the Raphanus has much the flavor of the most delicate radish, and is a great addition to a salad. When boiled, it should be served up on a toast like asparagus, which it resembles in flavor, but with a dash of the taste of early green peas added. The pods also make a good pickle.

Sources of Theine. — The Kola-nut of tropical West Africa, the seeds of which have from time immemorial been highly prized as a tonic by the natives of that region, have lately been shown by Mr. Daniell and Dr. Attfield, in two papers read by them before the Pharmaceutical Society, to contain theine. The Kola-tree (*Cola acuminata*, Robert Brown), also known by the name *Sterculia acuminata*, belongs to the natural order *Sterculiaceæ*. In Soudan its seeds are called " guru-nuts." It is the fifth source of the alkaloid theine or caffeine with which we are at present acquainted. The others are the tea-tree *Thea*, the coffee-tree *Coffea Arabica*, the Paraguay tree or maté *Ilex Paraguayensis*, and guarana *Paullinia sorbilis*. The seeds of the latter are extensively used in Brazil for the preparation of a sort of cocoa. It has often been remarked that theine is contained in the beverages in use among three-fourths of the human race. The discovery of this alkaloid in the kola-nut, which is mentioned by all African travellers as being an important article of commerce, still further confirms the truth of this remark.

Number of Useful Plants. — "Cosmos" states that, according to a German author, the number of useful plants has risen to about 12,000; but it must be remembered that these researches have been completed only in certain parts of the earth. There are no less than 2,500 known economic plants, among which are reckoned 1,100 edible fruits, berries, and seeds; 50 cereals; 40 uncultivated edible graminaceous seeds; 23 of other families; 260 comestible rhizomes, roots and tubers; 37 onions; 420 vegetables and salads; 40 palms; 32 varieties of arrowroot; 31 sugars; 40 saleps. Vinous drinks are obtained from 200 plants; aromatics from 266. There are 50 substitutes for coffee; 129 for tea. Tannin is present in 140 plants; caoutchouc in 96; gutta-percha in 7; resin and balsamic gums in 389; wax in 10; grease and essential oils in 330; 88 plants contain potash, soda, and iodine; 650 contain dyes; 47 soap; 250 fibres which serve for weaving; 44 are used for paper-making; 48 give materials for roofing; 100 are employed for hurdles and copses. In building, 740 are used; and there are 615 known poisonous plants. According to Endlicher, out of the 278 known natural families, 18 only seem, up to the present time, to be perfectly useless.

ASTRONOMY AND METEOROLOGY.

THE SOLAR SYSTEM.

The following catalogue has been compiled expressly for the "Scientific American," and embraces all the members of the solar system known up to January 1, 1866, except those comets whose elliptical orbits have not been well ascertained. Although America was late in the field of astronomical research, she has shared with the old world the glory of some of the grandest discoveries in astronomy. We can claim a new ring and satellite to the planet Saturn, eleven planets, and upwards of twenty comets: —

Name.	*By whom and when discovered.*	*Period of revolution.*
Mercury	The ancients.	88 days.
Venus	"	225 "
Earth	"	
Mars	"	1 yr 11 m
Ceres	Piazza, at Palermo, Jan., 1801.	4 yrs 7 m
Pallas	Olbers, Bremen, March 28, 1802.	4 yrs 7 m
Juno	Harding, Gottingen, Sept. 1, 1804.	4 yrs 4 m
Vesta	Olbers, Bremen, Dec. 29, 1807.	3 yrs 7 m
Astrea	Hencke, Driessen, March 8, 1845.	4 yrs 1 m
Hebe	" " July 1, 1847.	3 yrs 9 m
Iris	Hind, London, Aug. 13, 1847.	3 yrs 8 m
Flora	" " Oct. 18, 1847.	3 yrs 3 m
Metis	Graham, Ireland, April 25, 1848.	3 yrs 8 m
Hygeia	DeGasparis, Naples, April 12, 1849.	5 yrs 7 m
Parthenope	" " May 11, 1850.	3 yrs 10 m
Victoria	Hind, London, Sept. 13, 1850.	3 yrs 7 m
Egeria	DeGasparis, Naples, Nov. 2, 1850.	4 yrs 2 m
Irene	Hind, London, May 19, 1851.	4 yrs 2 m
Eunomia	DeGasparis, Naples, July 29, 1851.	4 yrs 4 m
Psyche	" " March 17, 1852.	5 yrs
Thetis	R. Luther, Bilk, Ger., April 17, 1852.	3 yrs 11 m
Melpomene	Hind, London, June 24, 1852.	3 yrs 6 m
Fortuna	" " Aug. 22, 1852.	3 yrs 9 m
Massilia	DeGasparis, Naples, Sept. 19, 1852.	3 yrs 8 m
Lutetia	Goldschmidt, Paris, Nov. 15, 1852.	3 yrs 10 m
Calliope	Hind, London, Nov. 16, 1852.	5 yrs
Thalia	" " Dec. 15, 1852.	4 yrs 2 m
Themis	DeGasparis, Naples, April 5, 1853.	5 yrs 7 m
Phocea	Chacornac, Marseilles, April 6, 1853.	3 yrs 8 m
Proserpine	R. Luther, Bilk, March 5, 1853.	4 yrs 4 m
Euterpe	Hind, London, March 8, 1853.	3 yrs 7 m
Bellona	R. Luther, Bilk, May 1, 1854.	4 yrs 7 m
Amphitrite	Pogson, Oxford, Nov. 1, 1854.	4 yrs 1 m
Urnia	Hind, London, July 22, 1854.	3 yrs 7 m
Euphrosyne	Ferguson, Washington, Sept. 1, 1854.	5 yrs 7 m
Pomona	Goldschmidt, Paris, Oct. 26, 1854.	4 yrs 2 m
Polhymnia	Chacornac, Paris, Oct. 28, 1854.	4 yrs 10 m
Circe	" " April 6, 1855.	4 yrs 5 m

Name.	*By whom and when discovered.*	*Period of revolution.*
Leucothea	R. Luther, Bilk, April 19, 1855.	5 yrs 2 m
Atalanta.	Goldschmidt, Paris, Oct. 5, 1855.	4 yrs 7 m
Fides	R. Luther, Bilk, Oct. 5, 1855.	4 yrs 4 m
Leda	Chacornac, Paris, Jan. 12, 1856.	4 yrs 6 m
Laetitia	" " Feb. 8, 1856.	4 yrs 7 m
Harmonia	Goldschmidt, Paris, March 1, 1856.	4 yrs 5 m
Daphne	" " May 22, 1856.	3 yrs 8 m
Isis	Pogson, Oxford, May 23, 1856.	3 yrs 10 m
Ariadne	" " April 15, 1857.	3 yrs 2 m
Nysa	Goldschmidt, Paris, May 27, 1857.	3 yrs 10 m
Eugenia	" " June 28, 1857.	4 yrs 6 m
Thestia	Pogson, Oxford, Aug. 16, 1857.	4 yrs
Aglia	R. Luther, Bilk, Sept. 15, 1857.	4 yrs 11 m
Doris	Goldschmidt, Paris, Sept. 19, 1857.	5 yrs 6 m
Pales	" " " "	5 yrs 5 m
Virginia	Ferguson, Washington, Oct. 4, 1857.	4 yrs 4 m
Nemansa	Laurent, Nismes, Fr., Jan. 2, 1858.	3 yrs 8 m
Europa	Goldschmidt, Paris, Feb. 4, 1858.	5 yrs 6 m
Calypso	R. Luther, Bilk, April 4, 1858.	4 yrs 3 m
Alexandra	Goldschmidt, Paris, Sept. 11, 1858.	4 yrs 6 m
Pandora	Searle, Albany, Sept. 10, 1858.	4 yrs 7 m
Mnemosyne	R. Luther, Bilk, Sept. 22, 1859.	5 yrs 7 m
Concordia	" " March 24, 1860.	4 yrs 5 m
Elpis	Chacornac, Paris, Sept. 12, 1860.	4 yrs 6 m
Danae	Goldschmidt, Paris, Sept. 9, 1860.	5 yrs 2 m
Echo	Ferguson, Washington, Sept. 14, 1860.	3 yrs 8 m
Erato	Lesser, Berlin, Sept. 14, 1860.	5 yrs 6 m
Ausonia	DeGasparis, Naples, Feb. 10, 1861.	3 yrs 8 m
Angelina	Tempel, Marseilles, March 4, 1861.	4 yrs 5 m
Cybele	" " " 8, 1861.	6 yrs 5 m
Maia	H. P. Tuttle, Cambridge, April 10, 1861.	4 yrs 4 m
Asia	Pogson, Madras, Ind., April 17, 1861.	3 yrs 8 m
Leto	R. Luther, Bilk, April 29, 1861.	4 yrs 7 m
Hesperia	Schiaparelli, Milan, April 29, 1861.	5 yrs 7 m
Niobe	R. Luthers, Bilk, Aug. 18, 1861.	4 yrs 7 m
Feronia	Peters, Clinton, N. Y., Jan. 29, 1862.	4 yrs 5 m
Clytia	Tuttle, Cambridge, April 7, 1862.	4 yrs 4 m
Galatea	Tempel, Marseilles, Aug. 30, 1862.	4 yrs 7 m
Euridice	Peters, Clinton, Sept. 22, 1862.	4 yrs 4 m
Freya	D'Arrest, Copenhagen, Oct. 23, 1862.	6 yrs 5 m
Frigga	Peters, Clinton, Nov. 12, 1862.	4 yrs 5 m
Diana	R. Luther, Bilk, March 15, 1863.	4 yrs 3 m
Eurynome	Watson, Ann Arbor, Sept. 14, 1863.	3 yrs 10 m
Sappho	Pogson, Madras, May 3, 1864.	3 yrs 6 m
Terpsichore	Tempel, Marseilles, Sept. 30, 1864.	4 yrs 10 m
Alcmene	R. Luther, Bilk, Nov. 27, 1864.	4 yrs 7 m
Beatrice	DeGasparis, Naples, April 26, 1865.	3 yrs 9 m
Clio	R. Luther, Bilk, Aug. 25, 1865.	3 yrs 7 m
Io	Peters, Clinton, Sept. 19, 1865.	4 yrs 4 m
Jupiter	The ancients.	11 yrs 9 m
Saturn	"	29 yrs 5 m
Uranus	W. Herschel, Slough, March 13, 1781.	84 yrs 10 m
*Neptune	Galle, Berlin, Sept. 23, 1846.	164 yrs 8 m

PERIODICAL COMETS.

Encke	Pons, Marseilles, Nov. 26, 1818.	3 yrs 4 m
DeVico	DeVico, Rome, Aug. 22, 1844.	5 yrs 5 m

* Theoretically discovered by Le Verrier and Adams prior to this date.

Name.	*By whom and when discovered.*	*Period of revolution.*
Winnecke	Winnecke, Bonn, March 8, 1858.	5 yrs 6 m
Brorsen	Brorsen, Kiel, Feb. 26, 1846.	5 yrs 6 m
Biela	Biela, Josephstadt, Feb. 26, 1826.	6 yrs 6 m
D'Arrest	D'Arrest, Leipsic, June 27, 1851.	5 yrs 3 m
Faye	Faye, Paris, Nov. 22, 1843.	7 yrs 4 m
Tuttle	Tuttle, Cambridge, Mass., Jan. 4, 1858.	13 ys 7 m
Peters	Peters, Constantinople, June 26, 1846.	12 ys 9 m
Halley		76 ys 3 m
Pons	Pons, Marseilles, July 20, 1812.	70 ys 8 m
Olbers	Olbers, Bremen, March 26, 1815.	73 y 11 m
Tuttle	Tuttle, Cambridge, July 18, 1862.	123 y 11 m
Peters	Peters, Albany, N. Y., July 25, 1857.	258 yrs
Tebbutt	Tebbutt, Australia, May 13, 1861.	415 yrs
Bremiker	Bremiker, Berlin, Oct. 22, 1840.	344 yrs
Donati	Donati, Florence, June 2, 1858.	1875 yrs

SATELLITES.

Earth.

Moon	The ancients.

Jupiter.

1 Io	Galileo, Padua, Jan. 7, 1610.
2 Europa	" " " " "
3 Ganymede	" " " " "
4 Calisto	" " " 13, "

Saturn.

1 Mimas	W. Herschel, Slough, Sept. 17, 1789.
2 Enceladus	" " Aug. 28, 1789.
3 Tethys	Cassini, Paris, March, 1684.
4 Dione	" " " "
5 Rhea	" " " Dec. 23, 1672.
6 Titan	Huygens, Hague, March 25, 1655.
7 Hyperion	G. P. Bond, Cambridge, Sept. 16, 1848.
8 Japetus	Cassini, Paris, Oct. 25, 1671.

Uranus.

1 Ariel	Lassell, Liverpool, Sept. 14, 1847.
2 Umbriel	W. Herschel, Slough, Jan. 18, 1790.
3 Titania	" " " " 1787.
4 Oberon	" " " " "

Neptune.

Not named	Lassell, Liverpool, Oct. 10, 1846.

Rings of Saturn.

1 Bright Ring	Galileo, Pisa, Nov. 12, 1610.
*2 Dusky "	G. P. Bond, Cambridge, Nov. 11, 1850.

In addition, have since been discovered: — Semele, by F. Tietjen, Berlin, Jan. 4, 1866. Sylvia, by Mr. Pogson, May 16, 1866. Thisbe, by C. H. F. Peters, June 15, 1866, at Hamilton College. Antiope, by Luther, at Bilk, the 90th of the series; and the 91st, unnamed, since discovered at the Observatory at Marseilles.

* C. W. Tuttle, assistant at the Cambridge Observatory, first suggested, in 1850, an interior dusky ring as a true explanation of the phenomenon discovered by Bond.

COMPOSITION OF THE SUN.

In a paper read before the Royal Institute, March 17, 1865, by Balfour Stewart, the following conclusions, based chiefly upon evidence afforded by photography, are given in relation to the composition of the sun.

1. The existence of an atmosphere around the sun, outside of its luminous envelope or photosphere. This is proved by the fact that photographs of the sun are less intense around the edges than in the middle, which is only to be explained on the supposition that an absorptive atmosphere surrounds the sun, causing more loss of power to the rays from the sides which must pierce it obliquely, and thus pass through a great depth, than to those from the centre, which penetrate it by the direct and shortest road possible.

2. That the "flames" or brilliant protuberances seen around the edges of the moon, in a total eclipse of the sun, belong to the central orb and not to the satellite. This was proved conclusively by a series of photographs taken during the eclipse of 1860, by De La Rue and others. In these, the flames are shown in the successive pictures to have suffered gradual occultation, and to have been gradually exposed in like manner by the moving planet, thus clearly being attached to or connected with the sun, and not in any wise related to the moon. These flames, supposed to be in fact detached portions of the luminous envelope, or extensions of the same into the solar atmosphere, above mentioned, were also shown to possess remarkable actinic power, their shapes being more developed and better defined on the photograph than to the eye, and one invisible portion producing a distinct image on the sensitive film.

3. That there are markings of a regular character over the solar disk, called, from their shape, willow-leaves, ripples, etc. These are distinctly visible on some photographs by Mr. Nasmyth.

4. That the spots in the sun are openings in its photosphere, through which its relatively dark mass is seen. This is fully demonstrated by the order in which the spot and its penumbra (the sloping sides of the opening) disappear as the luminary rotates.

SUN-SPOTS.

The different views of astronomers in regard to sun-spots are well illustrated by the following opinions: —

Mr. De La Rue and the Kew observers, after careful examination of the pictures of sun-spots, as observed by the heliograph and from Mr. Carrington's maps, have come to the following conclusions: 1. Sun-spots are cavernous; they lie below the general level of the sun's luminous matter, and extend into the regions beneath it. 2. The faculæ are portions of the sun's luminous matter elevated above the general level of the photosphere; and near the limb of the sun they appear relatively brighter than the surrounding surface, because, on account of their greater elevation, the light which they emit is less subject to absorption by the

sun's atmosphere. 3. The sun's luminous matter is of the nature of cloud. 4. The formation of spots on the sun is, in some way, influenced by the planet Venus. — *Ast. Notices*, 1865.

Before the French Academy was read a memoir on "An Inequality of the Apparent Movement of the Solar Spots, caused by their Depth," by M. Faye. The writer concluded as follows: 1. The spots are not due to projections or clouds placed above the photosphere. 2. They cannot be fairly compared to superficial strata. 3. They are apertures occurring accidentally in a luminous envelope, whose thickness, variable perhaps with latitude, appears to be about from 0.005 to 0.009 of the sun's radius 4. Many of the irregularities apparently so capricious, observed frequently by astronomers, and attributed either to a gyration analogous to our cyclones, or to a spontaneous tendency in the spots to separate from each other, or to the mutual influence of neighboring spots, are explained simply, either by the new inequality or by the continued variation of the proper movement from one parallel to another. 5. The astonishing regularity observable in the movements of the spots during entire months seems incompatible with all hypotheses which place the photosphere under the absolute dependence of currents developed external to the sun's nucleus. The progressive retardation of the rotation of the photosphere in proportion as the poles are approached, is so regular a phenomenon, and exerts itself through such an enormous depth, that it cannot be due to superficial agents, such as the cyclones.

The following is the remarkable opinion and theory of Sir John Herschel with regard to the nature of those curious objects discovered by Mr. Nasmyth, on the surface of the sun, and generally called, from their peculiar shape, "willow-leaves." We believe Sir John first propounded this theory in an article on the sun, published in "Good Words;" but it does not seem to have been noticed by many astronomers. However wild the hypothesis may appear, it has just received a further sanction from its eminent author, by its republication in his new book of "Familiar Lectures." Sir John says: "Nothing remains but to consider them [the so-called willow-leaves] as separate and independent sheets, flakes, or scales, having some sort of solidity. And these flakes, be they what they may, and whatever may be said about the dashing of meteoric stones into the sun's atmosphere, etc., are evidently the immediate sources of the solar light and heat by whatever mechanism or whatever processes they may be enabled to develop, and, as it were, elaborate, these elements from the bosom of the non-luminous fluid in which they appear to float. Looked at in this point of view, we cannot refuse to regard them as organisms of some peculiar and amazing kind; and though it would be too daring to speak of such organization as partaking of the nature of life, yet we do know that vital action is competent to develop both heat, light, and electricity." Strange and startling as is such an explanation, yet scientific men will remember that, when we knew as little about the cause of the black lines seen in the spectrum of the sun, as we now know about these appearances on the sun itself, Sir John Herschel suggested, in 1833, that very

explanation which was the foundation of the memorable law announced by the German philosopher, Kirchhoff, in 1859; a law now universally accepted as affording a perfect solution to the long standing puzzle of Fraunhofer's lines. — *Reader*.

BOLIDES.

A bolide is a planet in miniature; a small mass of matter, revolving round the sun in a longer or shorter elliptical orbit, obeying the same laws and governed by the same forces as the greater planets. Now, suppose the orbit described by a bolide to cross the orbit of the earth, exactly as one road crosses another; and, moreover, that the two travellers reach the point of junction or crossing at the very same time. A collision is the inevitable consequence. The bolide, which, in respect to size, is no more than a pebble thrown against a railway train, will strike the earth without her inhabitants experiencing, generally, the slightest shock. If individuals happen to be hit, the case will be different. If the earth arrive there a little before or after the bolide, but at a relatively trifling distance, she will attract it, cause it to quit its own orbit, dragging it after her, an obedient slave, to revolve around her until it falls to her surface. Or it may happen that the bolide may pass too far away for the earth to drag it into her clutches, and yet near enough to make it swerve from its course. It may even enter our atmosphere, and yet make its escape. But, in the case of its entering the atmosphere, its friction against the air will cause it to become luminous and hot, perhaps determining an explosion. Such are the meteors whose appearance at enormous heights our newspapers record from time to time.

Be it remarked that bolides are true planets, and not projectiles shot out from mountains in the moon, as has been conjectured. A projectile coming from the moon would reach the earth with a velocity of about seven miles per second. But the most sluggish bolide travels at the rate of nearly nineteen miles per second, fast goers doing their six-and-thirty miles in the same short space of time. None of the inferior planets travel so rapidly as that. Mercury, the swiftest of them all, gets over only thirty miles per second. Mr. Tyndall states that this enormous speed is certainly competent to produce the effects ascribed to it.

When a bolide, then, glances sufficiently close to our earth to pass through our atmosphere, the resulting friction makes its surface red hot, and so renders it visible to us. The sudden rise of temperature modifies its structure. The unequal expansion causes it to explode with a report which is audible. If the entire mass does not burst, it at least throws off splinters and fragments. The effect is the same as that produced by pouring boiling water upon glass. The fragments, falling to the ground, are aerolites. It is needless here to cite instances of their falling. They are of universal notoriety. Aerolites have no new substance to offer us. If the earth, therefore, be made up of atoms, we may conclude that the universe is made up of atoms. — *All the Year Round*.

ZODIACAL LIGHT.

The following letter from Chacornac was published in the "Reader," 1865: —

"The observation of the zodiacal light at the epoch of the winter solstice, in latitude 45°, is not a very extraordinary fact; but as I do not know any notice of it, it may be useful to mention how it appears under circumstances when it can be well observed. On the 23d December, 1864, we noticed here, at 6.45 P. M., that an intensely luminous portion of the zodiacal light plainly detached itself from the bottom of a gloomy sky. This could be traced to about the constellation Pisces. The sky was but indifferently clear. At the time of making this observation I sought to determine the quantity of light which this portion emitted, compared with that emitted by the stars. For this purpose I drew on paper several black lines between white ones of the same breadth, all equally distant. At seven in the evening, the zodiacal light appearing in all its intensity, I distinguished, with difficulty, the white lines, which were about a millimetre distant from the others. This limit of visibility was found even when precautions had been taken to obtain a great sensibility of the retina. On the night of the 29th and 30th December a diffused luminosity, which appeared to me to paint the sky, was certainly more intense than that seen on the 23d of the same month. Indeed, on the 30th, at 10 P. M., it was possible to distinguish white lines separated only the third of a millimetre from black lines of equal dimensions; it was impossible to do so on December 23. I next examined how this diffused light distributed itself, and saw that the most luminous part was above a whitish phosphorescent veil, which covered the horizon with a light and luminous mist; the intensity of the luminosity was therefore not uniformly distributed. Employing a photometric apparatus, and designating by unity the luminous intensity of the sky in the neighborhood of the horizon, at 25° high we had 1.53 for the expression of the intensity of the light of the sky at this point; overhead, the heavens deprived of stars, we had 1.15 for the intensity of the light in the region of the zenith. Thus, proceeding from the horizon, the luminous intensity of the sky increased up to a height of about 25°, and then decreased as we rose from this point to the zenith. At least, so it was on the 30th of December, 1864.

"If we admit that it may be light from stars which thus illuminates our atmosphere during serene nights, we do not explain why the stars should not be visible on a dark sky through a transparent atmosphere. The fine divisions of the instrument used, whilst they become visible when the atmosphere is less transparent, enable us to see a luminous veil interposing itself between the light of the stars and the observer. We know that all light-absorbing media radiate light; this medium, then, absorbing the light of the stars, radiates some light towards the earth. On the 30th December, from 10 to 11 P. M., and from midnight to 1 A. M., the phosphorescent veil was so intense that the milky-way could hardly be seen.

"During the night of December 30, I compared the relative brilliancy of two stars (*a*) and (*e*), marked on the map of M. Liapounon, in the great nebula of Orion. It is well-known that astronomers who have especially studied this nebula, have always indicated the star θ in Orion as the most brilliant of those within the nebulosity.

During several nights of this last autumn I remarked that the star (*e*) shone more brilliantly than θ, Orion, which it is near. In order to determine this, I placed a bi-refracting prism in the interior of a prismatic telescope, one metre thirty centimetres focal length, in such a manner as to cause the double image of the two stars to overlap each other. Successively alternating the ordinary with the extraordinary image of one of these stars, a series of comparisons was obtained, which plainly showed that (*e*) is more brilliant than (*a*) or θ, Orion. As M. Otto Struve has stated that there exists in this nebula a series of variable stars of feeble magnitude, I mention the result of the preceding comparison as one from which we should safely conclude that θ, Orion, was in another epoch of superior brilliancy to that of (*e*), which is marked in all our charts as being of the fifth magnitude. Indeed, another similar measure definitively established the fact that one of the two stars is variable. We well know what interest attaches itself to those variable stars of large magnitude which are surrounded by the diffused light of nebulous matter.

"In the foregoing observations it was necessary to superpose different regions of the nebula in order to eliminate the effects of contrast, or of superposition of the luminous matter. It is almost needless to say, that the intensity of the diffused light of the most brilliant regions of the nebula did not attain to a hundredth part of the brilliancy of θ, Orion, whilst the brilliancy of (*e*) surpassed this last, by a quantity far greater than the value of the intensity of the light emitted by the nebula."

M. Liandier, in "Comptes Rendus," states that he watched the zodiacal light in 1866, from Jan. 19 to May 5. He considers it to have the shape of a perfect cone, varying in luminosity and color from dull gray to silvery white, the changing aspect being probably due to the condition of our atmosphere. In February the summit of the cone reached the Pleiades, and the Twins in May. Between January and May he found it to follow the zodiacal movements of the sun. He believes the luminous cone to be a fragment of an immense atmosphere enveloping the sun on all sides. If so, he says it may be expected to exercise an enormous pressure on the sun, with great development of heat; and if local variations occur, he thinks they may explain the occurrence of spots through the reduction of temperature that would follow diminished pressure.

WHAT IS A NEBULA?

The following are the conclusions of Mr. Huggins: —

1. The light from the nebulæ emanates from intensely heated matter, existing in the state of gas. This conclusion is corroborated by the great feebleness which distinguishes the light from

the nebulæ. A circular portion of the sun's disk subtending 1′ would give a light equal to 780 full moons; yet many of the nebulæ, though they subtend a much larger angle, are invisible to the naked eye.

2. If these enormous masses of gas are luminous throughout, the light from the portions of gas beyond the surface visible to us would be in a great measure extinguished by the absorption of the gas through which it would have to pass. These gaseous nebulæ would, therefore, present to us little more than a luminous surface.

3. It is probable that two of the constituents of these nebulæ are the elements hydrogen and nitrogen, unless the absence of the other lines of the spectrum of nitrogen indicates a form of matter more elementary than nitrogen. The third gaseous substance is at present unrecognized.

4. The uniformity and extreme simplicity of the spectra of all these nebulæ oppose the opinion that this gaseous matter represents the "nebulous fluid" suggested by Sir William Herschel, out of which stars are elaborated by a process of subsidence and condensation. In such a primordial fluid, all the elements entering into the composition of the stars should be found. If these existed in these nebulae, the spectra of their light would be as crowded with bright lines as the stellar spectra are with dark lines.

5. A progressive formation of some character is suggested by the presence of more condensed portions, and, in some nebulæ, of a nucleus. Nebulæ which give a continuous spectrum, and yet show but little indication of resolvability, such as the great nebula in Andromeda, are not necessarily clusters of stars. They may be gaseous nebulæ, which, by the loss of heat or the influence of other forces, have become crowded with portions of matter in a more condensed and opaque condition.

6. If the observations of Lord Rosse, Prof. Bond, and others, are accepted in favor of the partial resolution of the annular nebula in Lyra, and the great nebula in Orion, into discrete bright points, these nebulæ must be regarded not as simple masses of gas, but as systems formed by the aggregation of gaseous masses.

7. The opinion of the enormous distance of the nebulæ from our system, since it has been founded upon the supposed extent of remoteness at which stars of considerable brightness would cease to be separately visible in our telescopes, has no longer any foundation on which to rest, in reference at least to those of the nebulæ which give a spectrum of bright lines. It may be that some of these are not more distant from us than the brighter stars.

8. As far as his observations extend, they appear to be in favor of the opinion that these nebulæ are gaseous systems possessing a structure and a purpose in relation to the universe, altogether distinct from the great cosmical masses to which the sun and the fixed stars belong. — *Lecture before the Royal Institution.*

LUMINOUS METEORS.

The following are extracts from the "Reader," 1865, in relation to papers of M. St. Claire Deville, Newton, and Herschel, on the subject of meteors: —

When we consider the observations of M. Quetelet, which indicate a connection between the appearances of shooting stars and auroræ and those which correlate these latter with solar and magnetical phenomena, we can scarcely be surprised to hear that the temperature of our atmosphere is affected by them.

In a paper recently presented to the Paris Academy by M. Ch. Saint-Claire Deville, he attempts to show a most intimate connection between these phenomena.

It is now generally held that these little bodies which we are now weighing and numbering are not scattered uniformly in the planetary spaces, but are collected into rings — tangible orbits — round the sun, and that it is when our earth in its orbit breaks through one of the rings or passes near it that its attraction overpowers that of the sun, and causes them to impinge on our atmosphere, when, their motion being arrested and converted into heat, they become visible to us as meteors, fire-balls, or shooting stars, according to their size.

Thus we have one ring which furnishes us with the August meteors, and another through which we pass in November. The position of these rings in space is very different; for while the November one lies almost in the same plane as that in which the earth's annual course is performed, that of the August shooting stars is considerably inclined to it, and its nodes are situated at the extremities of its major axis. There are also other points of difference; for while the nodes of the August ring are stationary, those of the November one have a direct proper motion. Now, M. Deville has, in the most crucial manner, examined the temperature of the months of August and November since 1806, and has detected the fact that in both the months there is an increase of temperature about the period of the star showers, and a decrease of temperature in February and May, *i. e.*, in the mid interval between these annual showers in both months. The existence of anomalies in the temperature of these four months has long puzzled meteorologists, and various causes have been assigned; but the curves which M. Deville has prepared enable him to affirm that the temperature which each day of those months should possess, by virtue of the earth's place in the ecliptic, is affected by a certain coefficient depending upon cosmical causes. To explain this, he reproduces the theory of Erman, that the lowering of the temperature in February and May is caused by the interposition of the meteor rings between us and the sun, causing an "obfuscation" of that luminary, and that the increase of temperature in August and November is caused by their preventing the radiation of heat from our globe, and possibly by radiating towards us part of the heat they themselves receive from the sun. Since this theory was enunciated by Erman, there have been several objections made to it, and M. Faye has shown, since M. Deville's paper was

read, that it must be accepted with caution; but there are additional reasons that the subject should be well inquired into.

The next contribution to our knowledge of these subjects we owe to Mr. Newton, in a paper read before the American National Academy of Sciences. Among the questions dealt with are the number of shooting stars that come into our atmosphere each day, the number of telescopic shooting stars, and the distribution of the orbits of the meteoroids in the solar system. He finds that the average number of meteors which traverse the atmosphere daily, and that are large enough to be visible to the naked eye, on a dark, clear night, is no less than 7,500,000; and applying the same reasoning to telescopic meteors, their numbers will have to be increased to 400,000,000! If allowance be made for the space occupied by the earth's atmosphere, we find that, in the mean, in each volume of the size of the earth, of the space which the earth is traversing in its orbit about the sun, there are as many as 13,000 small bodies, each body such as would furnish a shooting star, visible under favorable circumstances to the naked eye. If telescopic meteors be counted, this number should be increased at least forty-fold.

Mr. Newton remarks with the true caution of a philosopher: —

There are at least three suppositions respecting the distribution of the orbits of the meteoroids in the solar system which are naturally suggested. Either of them may be considered as plausible, and one does not exclude another.

1. They may form a number of rings, like the August group, cutting or passing near the earth's orbit at many points along its circuit. The sporadic shooting stars may be outliers of such rings.

2. They may form a disk in or near the plane of the orbits of the planets.

3. They may be distributed at random, like the orbits of the comets.

According to the first of these suppositions, there should be a succession of radiants corresponding to the several rings. Dr. Heiss and Mr. R. P. Gregg believe that they have detected such a series.

Observations show a mean velocity greater than that of a parabolic orbit. We must regard as almost certain (on the hypothesis of an equable distribution of the directions of absolute motions), that the mean velocity of the meteoroids exceeds considerably that of the earth; that the orbits are not approximately circular, but resemble more the orbits of the comets.

These bodies cannot be regarded as the fragments of former worlds. They are rather the materials from which the worlds are forming.

Mr. Herschel has also communicated a paper on the "Progress of Meteoric Astronomy during the Year 1863–4" to the Astronomical Society. He dwells especially on the very close correspondence of the observations undertaken to determine their height. It appears from this comparison that the heights of shooting stars at Rome are sensibly the same as in those latitudes of Northern Europe where shooting stars have chiefly been observed; and these

heights may be stated to be, respectively, 73 and 52 miles, at first appearance and disappearance above the surface of the earth, with a probable error of not more than two or three miles. The average velocity of shooting stars in sixty-six instances is 34.4, or, in round numbers, 35 miles per second. Fifty-six general radiant points of shooting stars have now been shown to exist in different seasons of the year, which represent, with a considerable degree of accuracy, the whole of the available observations recorded up to the present time in existing catalogues. These general radiant points belong to fifty-six annual star showers, as well determined, in the majority of cases, as to limits of their duration and positions of their radiant points, as is the case with the older and better-known showers of August and November. The currents, zones, or belts of meteors which they indicate, encompassing the sun, are more or less rich and long-enduring. They appear to give rise to occasional star-showers by particular concentrations of their materials —perhaps even to fireballs — by a still closer compacting of their particles.

M. Liandier has communicated to "Les Mondes" the following conclusions, which embody the result of three years' observation: "The shooting stars which leave no trace of their trajectories travel in the same direction as the dominant air currents of the upper regions of the atmosphere at the time; those with trains in the opposite direction."

PHYSICAL HISTORY OF METEORITES.

The following are extracts from a communication of Mr. H. C. Sorby, F.R.S., to "Silliman's Journal," of January, 1866: —

"As shown in my paper in the 'Proceedings of the Royal Society' (xiii. 333), there is good proof of the material of meteorites having been to some extent fused, and in the state of minute detached particles. I had also met with facts which seem to show that some portions had condensed from a state of vapor, and expected that it would be requisite to adopt a modified nebular hypothesis, but hesitated until I had obtained more satisfactory evidence. The character of the constituent particles of meteorites, and their general microscopical structure, differ so much from what is seen in terrestrial volcanic rocks, that it appears to me extremely improbable that they were ever portions of the moon, or of a planet, which differed from a large meteorite in having been the seat of a more or less modified volcanic action. A most careful study of their microscopical structure leads me to conclude that their constituents were originally at such a high temperature that they were in a state of vapor, like that in which many now occur in the atmosphere of the sun, as proved by the black lines in the solar spectrum. On cooling, this vapor condensed into a sort of cometary cloud, formed of small crystals and minute drops of melted stony matter, which afterwards became more or less devitrified and crystalline. This cloud was in a state of great commotion, and the particles moving with great velocity were often broken by collision. After collecting together to form larger

masses, heat, generated by mutual impact, or that existing in other parts of space through which they moved, gave rise to a variable amount of metamorphism. In some few cases, when the whole mass was fused, all evidence of a previous history has been obliterated; and, on solidification, a structure has been produced quite similar to that of terrestrial volcanic rocks. While these changes were taking place, various metallic compounds of iron were so introduced as to indicate that they still existed in free space in the state of vapor, and condensed among the previously-formed particles of the meteorites. I therefore conclude, provisionally, that meteorites are records of the existence in planetary space of physical conditions more or less similar to those now confined to the immediate neighborhood of the sun, at a period indefinitely more remote than that of the occurrence of any of the facts revealed to us by the study of geology, — at a period which might, in fact, be called pre-terrestrial."

In the same journal will be found a paper, by the same author, on the "Mineralogical Structure of Meteorites." See also, for the same subject, "Quarterly Journal of Science," July, 1866.

METEORIC SHOWER OF NOVEMBER, 1866.

The meteoric shower predicted on the 13th of November, 1866, though unobserved in America, was of extraordinary brilliancy in Europe. A full account of the appearances, as seen in Great Britain, France, and Spain, condensed from the London journals, will be found in the "New York Herald" of Nov. 28, 1866, and the "Boston Transcript" of the same date. We have only space for the following extracts from a letter of Mr. T. L. Phipson, to the "London Reader," from which an idea of the magnificence of the display may be obtained: —

"Last night, November 13, 1866, will remain forever a period of extraordinary interest to astronomers. The conjectures of Humboldt and others, that the November period of falling stars attains its maximum every thirty-three years, is now a certain fact. The sight, indeed, will long remain stamped upon my memory. All who are familiar with these wonderful phenomena, know that a large fall of meteors was expected between the 11th and 14th of November, 1866, — probably on the night of the 13th. The star-shower has happened, as predicted, and a more extraordinary sight it was not possible to witness.

"I began to observe early, knowing that the large meteors generally show themselves shortly after sunset, and at twenty minutes past nine I saw the first meteor. It rose directly from the horizon (my windows looking N.N.E.), from the direction of the constellation *Leo*, which had not yet risen. It mounted rather slowly at first, like an ordinary rocket, which I took it to be, but it rose still higher and higher, and shot away to the other side of the heavens, passing directly over my head. It was the finest shooting star I ever saw, and augured well for the expected swarm, as it certainly was an out-lier of the November group, differing rather, in color, from those of August, etc., and issuing

from that portion of the heavens directly above the constellation *Leo*. . . . Before I had finished observing, I saw meteors at the rate of considerably more than 2,500 per hour! In fact, from half-past twelve to half-past one, it was impossible to count them, though two of us endeavored to do so.

"As a gross approximation only, it may be stated that about one o'clock the stars fell at the rate of 2,550 per hour.

"Of the whole of these thousands of shooting stars which I must have witnessed last night, only five issued from various portions of the heavens, the rest all radiated from the constellation *Leo*.

"The weather was fortunately clear, but a strong wind was blowing, which became quite boisterous during the most brilliant period of the phenomenon. It was doubtless a storm-wind, for I noticed the reflection or radiations of several flashes of lightning from below the N.W. and N.N.E. horizon, namely, one flash at twenty minutes past nine, two flashes about five minutes past ten, one flash at half-past ten in the N., one flash at ten minutes to eleven, and one flash at one o'clock. I should like to be sure that these electric radiations emanated from a storm below the Northern horizon, or whether they must be considered identical with the luminous radiations formerly noticed in "Cosmos" (1852 and 1853), as accompanying, sometimes, the phenomenon of shooting stars."

IMPROVED APPARATUS FOR ASTRONOMICAL OBSERVATION.

Prof. Rutherford, at the last meeting of the National Academy, exhibited photographs of his inventions. He had seen, in May, 1865, that he could never succeed in taking photographs with the achromatic objective; the visual and actinic focus not colliding, and it being impossible to correct the plate except very near to the centre of the field. Tremors in the moist atmosphere of New York city increased his difficulties, injuring silvered mirrors so that it was necessary to coat them every two or three days. In 1863 he had decided that it was useless to attempt a telescope which should bring the visual and actinic foci to one plane; it would have been a useless compromise, sacrificing the best qualities of both; and, after many experiments, he had succeeded in producing a photographic telescope, useless for vision, but giving excellent results. In this, the red, yellow, and green rays, which retard action, are dissipated. The image is taken on a screen of collodion. He had taken plates of the sun and moon; but the chief value of his work was in its stellar application. He wished to show that something was always lost in methods purely mechanical, the human eye having a power of adaptation not conferred on any lens. Thus a finder of four and a half inches would give to the eye what the eleven and a half inch lens could not report. The atmosphere is a great disturber. All observers know what it is to have stars jump double their own distance on the field. Photography locates exactly. Of the moon it furnishes a fine map, to be filled in by accurate observation afterwards. He showed how the errors occasioned by reducing the curves in the heavens to a plane surface

were to be obviated. In this actinic telescope how can we find the true focus? Only by a process of tentation which he explained. It has no power of accommodation, and records changes of the one-hundredth of an inch, which the visual telescope cannot; nor will any two actual observers ever agree to within the one-hundredth of an inch on any focus.

To show the advantages of this glass in stellar work, he showed that it had taken images of stars of the ninth magnitude; stars of the sixth being the smallest before recorded. He had begun to work on the Pleiades, Bessel's work on this constellation being so accurate as to make it the best test of his own work. One plate, exposed three or four minutes, gave him forty-three stars. On that, Alcyone occupied twenty seconds, which was such an enormity that it required examination. He found this extraordinary breadth to proceed from her own light, increased by radiation within the tube of the instrument, and showed how a bit of gauze removed the difficulty. This breadth was filled up by repeated impressions, not by an instant's exposure and printing. The telescope follows the star in a prolonged exposure; if it is not quite prompt, it only elongates the star in the direction of right ascension. He had at first apprehended trouble from the shrinking of the collodion. It had not come; if it did, he had still a resource in a certain tenacious varnish. Now, to ascertain the worth of his work, a micrometer was necessary. None in existence could be adapted to this instrument, so this also he must make himself. He described this achievement, and showed a photograph of it. The extraordinary accuracy of the work done by it we can only measure by the amazement of the authorities present, who pressed eagerly about him. He described his eye-piece with its bisecting lines. He believed that, henceforth, no observatory would be complete without a recording glass. He showed, in conclusion, how he had forced the light into the right direction within the tube by a supplementary lens.

SECULAR INCREASE OF MEAN TEMPERATURE.

Before the London Meteorological Society, Mr. Glaisher read a communication on the "Secular Increase of Mean Temperature." He stated that the mean temperature of the seven years ending 1863 had been so high as to increase the mean temperature of the year from forty-three years' observations, viz., 48° 92′ to 49° 04′. He then remarked that the mean temperature of the first twenty-five years ending 1838 was 48° 6′, and of the twenty-five years ending 1863 was 49° 2′. The author then became desirous to see if this increase had been progressive, and found the mean of twenty-nine years ending 1799 was 47° 7′, of thirty years ending 1829 was 48° 5′, and of thirty years ending 1859 was 45° 0′, proving that the secular increase of the mean temperature was 2°. This result he considered so important that he examined every probable source of error, and concluded that no instrumental errors would account for this increase. The questions he then set himself to investigate were: Whether this increase had taken place in every month in the year? or in some months or seasons

more than others? and he found a remarkable difference in the winter months; the greatest in January, whose mean temperature in the twenty-nine years ending 1799 was 34° 7′; the mean of the next thirty years was 35° 7′, and of the last thirty years was 37° 5′, and every season showed increase. The author then selected every day of remarkably low and remarkably high temperature, and divided the results into groups, and it appeared that in the twenty-five years ending 1838 there had been seventy-two days in January whose mean temperature had been below 25°, and fourteen only of such low temperatures in the last twenty-five years, whilst in the former period there had been seventy-five days of temperature higher than 45°, and 109 days of temperature exceeding 45° in the latter. He treated every month in the same way, and discussed the early observations and descriptions of years in the last century, and concluded, — that our climate in the last hundred years has altered; that the mean temperature of the year is now 2° higher than it was one hundred years ago; that the month of January is nearly 3° warmer; that frosts and snow-showers are of very much shorter duration and less in amount; and he concluded his paper by expressing a hope that series of observations in progress over the world will be patiently continued; — for other questions now open themselves, for instance, has any part of the world lost 2° of annual temperature? or has the world itself increased in warmth? Other questions also press, so as to make it extremely desirable that similar determinations should be made as soon as possible at other parts of the world.

CLIMATE OF BRAZIL.

According to Professor Agassiz, in his lecture before the Lowell Institute, in Boston, Mass., in October, 1866, the climate of the Amazonian basin differs from that of other regions in the same latitude, by reason of the great moisture prevailing there. The combination of heat and moisture, he observed, produces a more luxuriant vegetation than is to be found anywhere else.

There are not four distinct seasons, as with us; but perpetual summer reigns. There is more or less of rain throughout the year, but no such special period of great prevalence as marks the climate of other tropical regions, where a very dry season succeeds months of copious rain. The rains do not prevail over all sections at the same time, but beginning at the south in September, they progress northward till they reach Guiana in March and April. As a consequence, when the southern tributaries of the Amazon are most swollen, the northern tributaries are at their lowest ebb, and *vice versa;* and thus a balance is maintained between the upper and lower parts of the basin.

Again, there is a difference between the course of the main stream at its most western origin, and at its mouth. The swelling waters of the Madeira reach the Amazon in November or December. The northern tributaries pour in their waters at a later period. The great increase in the Amazon at its confluences, by temporary coincidences in the flow of its tributaries, is in or near

the month of March, when the water rises a foot in each twenty-four hours, until it reaches a height of thirty-five feet above the ordinary level. The Amazon is lowest in October.

He said that the temperature of the whole valley was remarkably even, varying from the minimum to the maximum not more than fifteen degrees. The temperature of the water of the Amazon is also even, the maximum being 84 degrees, and the minimum 78. Other streams show as little variation in this respect. In consequence of this evenness of temperature, there is a feeling of comfort most agreeable to the inhabitants.

ASTRONOMICAL AND METEOROLOGICAL SUMMARY.

Stars of the Northern Hemisphere. — In the last edition of his "Wunder des Himmels," Prof. Littrow gives a summary of the number of stars that are in Argelander's charts of the Northern hemisp here.

From N. declination	0° to 20°,	110,987 stars.
" " "	20° to 40°,	105,082 "
" " "	40° to 90°,	108,131 "

Classified according to magnitude, there are: —

Mag.	*No. of Stars.*	*Mag.*	*No. of Stars.*
1—1.9 . . .	10	6—6.9 . . .	4,328
2—2.9 . . .	37	7—7.9 . . .	13,593
3—3.9 . . .	128	8—8.9 . . .	57,960
4—4.9 . . .	310	9—9.9 . . .	237,544
5—5.9 . . .	1,016		

There are, besides these, sixty nebulæ, and sixty-four variable stars.

Duration of the Flight of Shooting Stars. — Dr. Schmidt, director of the Observatory of Athens, has recorded as the result of his observations on shooting stars during the last eight years, and especially on the duration of flight of 1,357 meteors out of about 16,000 seen. The mean duration of those of different colors was: Of 846 white shooting stars, 0s.709; of 361 yellow, 0s.947; of 101 red, 1s.787; and of 49 green ones, 2s.685. The mean of all was 0s.925. As he has been accustomed to estimate small intervals of time, his estimates are deserving of confidence.

Height of Auroral Arches. — Mr. B. V. Marsh has obtained data for computing the approximate altitudes of three auroral arches, observed in Pennsylvania, Maine, and Massachusetts, on January 16, February 20, and February 21, 1865; the estimated altitudes were respectively 97, 80, and 57 miles, — or a mean altitude of 78 miles.

The Sky an Indicator of the Weather. — The color of the sky, at particular times, affords wonderfully good guidance. Not only does a rosy sunset presage good weather, and a ruddy sunrise bad weather, but there are other tints which speak with equal clearness and accuracy. A bright yellow sky, in the evening, indi-

cates wind; a pale yellow, wet; a neutral gray color constitutes a favorable sign in the morning. The clouds are again full of meaning in themselves. If their forms are soft, undefined, and full feathery, the weather will be fine; if their edges are hard, sharp, and definite, it will be foul. Generally speaking, any deep, unusual hues betoken wind or rain; while the more quiet and delicate tints bespeak fair weather. These are simple maxims, and yet not so simple but that the British Board of Trade has thought fit to publish them for the use of sea-faring men.

The Climate of Southland, New Zealand — The chief point of interest noticed by Mr. Marten, treating of the climate generally, is the remarkable example it affords of a rule long suspected to exist, and which the experience of each successive year seems more fully to establish. "Comparing the meteorological records of the temperate zone in the two hemispheres, I was struck with the fact that the meteorological characteristics of each season in the northern hemisphere were invariably reproduced in the following year at all places similar in geographical and isothermal position and natural features in the southern hemisphere. The question naturally arises, 'Is this mere coincidence?' That, of course, I cannot answer decisively; but my impressions are in the negative."

Meteorological Perturbations. — According to a paper recently laid before the Royal Geographical Society of Vienna by Dr. Friedman of Munich, the meteorological perturbations are due to "contact of the external air with the interior of the earth!" His reasoning is in this wise: According to Humboldt, there exist 425 volcanoes, of which 207 are still active. The external atmosphere is thus connected with the interior of the earth by 207 fiery throats. It may be assumed that of these 207 volcanoes there is at least one eruption daily, which thus causes important disturbances in the upper layers of the atmosphere. These movements being propagated in a wave-like manner to a distance, produce the irregularities in meteorological phenomena for which so many explanations have been proposed.

The Appearance of the Sun from the North Pole. — To a person standing at the north pole, the sun appears to sweep horizontally around the sky every twenty-four hours, without any perceptible variation during its circuit in its distance from the horizon. On the 21st of June, it is 23 degrees and 38 minutes above the horizon, — a little more than one-fourth of the distance to the zenith, the highest point it ever reaches. From this altitude it slowly descends, its track being represented by a spiral or screw with a very fine thread; and in the course of three months it worms its way down to the horizon, which it reaches on the 23d of September. On this day it slowly sweeps around the sky, with its face half hidden below the icy sea. It still continues to descend; and, after it has entirely disappeared, it is still so near the horizon that it carries a bright twilight around the heavens in its daily circuit. As the sun sinks lower and lower, this twilight grows gradually fainter till it fades away. On the 20th of December the sun is 23 degrees and 38 minutes below the horizon, and this is the midnight of the dark winter of the pole. From this date the

sun begins to ascend, and after a time his return is heralded by a faint dawn, which circles slowly around the horizon, completing its circuit every twenty-four hours. This dawn grows gradually brighter; and on the 20th of March the peaks are gilded with the first level rays of the six months' day. The bringer of this long day continues to wind his spiral way upwards till he reaches his highest place on the 21st of June, and his annual course is completed.

Power of Stars in Overcoming Twilight. — The following are extracts from a letter from M. Babinet to Admiral Smyth, published in the "Astronomical Register": —

"Another sidereal quality I have observed with great interest is, that some stars have more power of overcoming twilight than others of the same magnitude. The fact was published some years ago. Now as to the cause: Let us suppose a star just sufficiently bright to be perceived in twilight; its light, then, must be equal to at least one-sixtieth of the uniform light of the sky. But if we imagine that this star, preserving the same brightness, is smaller, and thereby occupies only one-fourth of the space it did before, then its light will be one-fifteenth of the general light of the sky, and will consequently be very perceptible. One of the stars of Cassiopeia possesses this power of conquering twilight; so does γ Draconis, ϵ Pegasi, and others. It is easy to prove this by ar optical experiment.

GEOGRAPHY AND ANTIQUITIES.

CONTRIBUTIONS TO AFRICAN GEOGRAPHY.

At the meeting of the Geographical Section of the British Association, in 1866, Sir C. Nicholson, the President, alluded to the discovery of the Lake Albert-Nyanza by Sir Samuel Baker, and described the nature of the problem which now remained to be solved in the geography of this part of Africa. This was the connection or separation of the two great inland seas, the Tanganyika and the Albert-Nyanza. The difference of level between them — eight hundred feet—militated against the supposition of their union; but a doubt existed as to the correctness of the levels given in the case of the Tanganyika, the measurement having been made by Burton and Speke, with a single and very imperfect instrument. It was hoped that this point might be settled by Livingstone, the last news from whom informed us of his arrival at the mouth of the Rovuma River, on the East Coast, whence he was about to travel by land into the interior. The road to the great southern lake, Nyassa, was reported to be open, and this distinguished traveller was, in all probability, now on his march.

Exploration of the Sources of the Nile. — Sir Samuel Baker said that, from its extraordinary fertilizing capacity in Lower Egypt, the Nile had, from the most ancient times, been looked on with great interest as respected its source and the cause of its periodically overflowing. The White Nile, which was the true Nile, issued from the Albert-Nyanza Lake, discovered by Speke and Grant, and that from the Victoria-Nyanza, between which a true river flowed. Flowing northward, the Nile, properly so called, traversed an enormous tract of marsh; and for some months of the year this tract was little more than a sandy, reedy plain. The river was filled with vegetable matter; but the junction of the Blue Nile with it at a lower point somewhat purified it. The regions of Lakes Victoria-Nyanza and Albert-Nyanza received an immense rainfall, as did the Abyssinian mountains, whence the Blue Nile flowed. In a single night, at the commencement of the rainy season, the river at particular points rose to a height of thirty feet in the course of a few minutes, so sudden and so copious is the rainfall in those lofty regions. This was really the effective cause of the periodical overflowing of the Nile.

Mr. Paul B. Du Chaillu, at the meeting of the Geographical Society, Jan. 8, 1866, read a paper "On a Second Journey into Western Equatorial Africa." In 1864 he advanced eastward into the Ashira country, which rises by successive steps from the coast. First, there is the belt of low land near the sea; then a succession of hilly ranges running north-west and south-east, with valleys

between, the ranges increasing in altitude towards the interior, and the passes over them ranging between 1,864 and 2,400 feet. The greater part of the country is covered with dense forest, through which are narrow paths leading from village to village; but from the Ashira country eastward there are three main lines of path, — one to the north-east, another to the east, and the third to the south-east. The tribes are divided into clans, and each village has its own chief, the inhabitants always belonging to the clan of the mother. The villages are more populous and larger than those near the coast. In reading the works of Grant, Speke, and Burton, he observed many words which were identical with, or which closely resembled, words used in the district he had traversed, and he had no doubt that the tribes of Western and Eastern Africa had formed originally one people.

From the accidental killing of two of the natives, he was obliged to abandon his journey, losing a great part of his valuable collections and scientific observations.

At the meeting of the British Association, in 1866, Mr. Du Chaillu made a communication on the physical geography of this region, from which the following are extracts: —

"There can be now no question that Equatorial Africa, from the West Coast. forms a belt of impenetrable jungle as far as I have been, to 13° 30′ east longitude. This jungle did not stop there, but could be seen as far as my eyes could reach, and the natives had never heard where it ended. The breadth of this gigantic forest extends north and south of the equator, probably from two or three degrees on each side. Now and then prairies, looking like islands, are found in the midst of this dark sea of everlasting foliage, and how grateful my eyes met them no one can conceive unless he has lived in such a solitude. At a certain distance from the coast, the mountainous region beyond rises almost parallel with it. This range of mountains seems to gird almost all the West Coast. Between these mountains and the sea, the country I have explored is low and marshy, and numerous rivers and streams are found. The low land is alluvial, and has no doubt been formed in the course of time by the washing of a deposit coming from the table-land. Only two rivers seem to pierce through these mountains. These are the Rembo Okanda and the Rembo Ngouyai, the one coming from a north-east direction, the other from the south-east. These two rivers unite and form the Agobia, which discharges itself into the sea, forming the delta which I have described in my book on 'Equatorial Africa,' and for which I had proposed the name of the Delta of the Agobia. Lieut. Labigot, of the French navy, and M. Touchard, have visited in a steamer the junction of the Okanda and Ngouyai. How far eastward this immense belt of woody country extends, further exploration alone can show. In this great woody wilderness man is scattered and divided into a great number of tribes. I was struck by the absence of those species of animals which are found in almost every other part of Africa, and I wondered not at it, for the country was unlike those parts which had been explored before. I found neither lion, rhinoceros, zebra, giraffe, nor ostrich. The great number of species

of elands, gazelles, etc., found everywhere else, were not to be seen. The forest, thinly inhabited by man, was still more scantily inhabited by beast. Now and then, by the side of the wild man, roamed the apes, among them the savage gorilla. There were no beasts of burden, no horse, no camel, no donkey, no cattle; man, or rather woman, was the beast of burden. Often miles were travelled over without hearing the sound of a bird, the chatter of a monkey, or the footsteps of a gazelle."

For remarks on the climate and the condition of the people, see Reports of the British Association for 1866.

GEOGRAPHY OF BRAZIL.

According to Prof. Agassiz, in his Lowell Lectures in Boston, Oct., 1866, one great feature of the river is that it has no delta, or projection of accumulated mud extending into the sea, like the Mississippi, the Nile, and the Ganges. Yet it carries an immense amount of mud in its waters. This is explained by the fact that owing to a combination of circumstances not yet unravelled, the ocean encroaches at a fearful rate on the continent north of the eastern promontory of Brazil. Above that point the coast of Brazil ran nearly north, so that a belt two or three hundred miles wide has already disappeared. The Amazon once extended three hundred miles beyond its present mouth. Whether it is owing to the softness of the soil or the configuration of the coast, the lecturer was unable to say. There is no subsidence at the ocean shore.

The waters of the Amazon, and the peculiarities of its physical attributes, are very different from what we have been accustomed to hear and read of them. The whole Amazonian basin is a vast plain. There are no hills, but an immense expanse of woods and water. The distance from the source of the Amazon in the Andes to the Atlantic Ocean, is two thousand miles in a direct line, but by the course of the river four thousand miles. The plain through which the river and its tributaries flow is twelve hundred miles wide, and in some places eighteen hundred. It is so low that the whole slope from the Andes to the Atlantic is not over two hundred and fifty feet. It cannot be compared to an ordinary river valley, and the river itself is different from all others in the world. Its mouth is one hundred and sixty miles wide, and its mud tinges the ocean for a long distance. Lakes and lagoons are numerous. In August and September the snow on the Andes begins to melt; but its influence is very slowly felt by the Amazon, the lower section not feeling the rise till the month of March. The river is highest from June to October. The rise is not less than thirty, and sometimes exceeds fifty feet. By a singular operation of natural causes, the southern tributaries of the Amazon are fullest when those on the northern bank are lowest, and *vice versa.* There are times when the whole basin is under water, and the dense forests may be navigated.

The color of the water in the streams flowing from the Andes is turbid, a sort of cream color, while that in the tributaries from the plains is black. These latter carry along such immense amounts

of sediment, that the cream-colored streams produce no visible effect on the color of the Amazon, which colors the ocean for fifty miles from the main land, so dense is its blackness. The colossal dimensions of this water system can hardly be conceived, and surpass everything of the kind in the world.

ATLANTIC AND PACIFIC SHIP CANAL.

Rear-Admiral C. H. Davis, in response to a call from the Secretary of the Navy, has recently presented a very full and interesting report on the different routes of this great plan of interoceanic communication across the Isthmus of Panama. Leaving out of view, as impracticable, the Tehuantepec and Honduras routes, he discusses at length the Nicaragua, Panama, and Atrato localities. Of these, he regards the most practicable route, that across the Isthmus of Darien, from the Gulf of San Miguel to Caledonia Bay. On this route, at both ends of the line, are spacious harbors, admirable in every respect; and, on the south side, there is a height of tide suited to the construction of docks for repairs. This line cuts the Cordilleras at a depression at least thirty feet below any that has ever been reported, and several hundred feet lower than any that has been surveyed. The course is direct, free from obstructions, healthy, while its outlets open upon coasts where violent storms rarely occur. The Savana river itself would form a part of the canal. No locks nor tunnels would be required. The canal on this line would be about twenty-seven miles long, only two of which would pass through hard rock. This falls far short of the Mont Cenis tunnel for difficulty; and the advantages of connecting the continents in this way are of incalculable importance. It is published in the "New York Herald" of Dec. 24, 1866.

THE BONE-CAVES OF BELGIUM.

The probable antiquity of man must be admitted on every hand to be the great scientific question of the day. Whatever, therefore, tends to throw light on this subject is of first importance. There can be no doubt that in our own Brixham cavern, beneath stalagmites of enormous size, relics of human work were found side by side with the bones of now extinct animals. Probably of less remote antiquity, but still of high interest, are the remains found in the Furfooz caves in the Belgian province of Namur. Their discovery was deemed of so great an importance that the Archæological Academy of Belgium, at the expense of the Government, sent a commission to examine these caves. On March 26, the commission issued their report, the substance of which we subjoin.

The Belgian Commission were immediately struck with the large number of reindeer horns, of which quantities have been found in one of the caves called Trou de Nutons. It is obviously important, though difficult, with precision to fix the exact epoch at which the reindeer moved northwards, a migration which must have been caused by some climatal change. According to the

opinion of MM. Lartet, Christy, Milne-Edwards, and others, the disappearance of the reindeer from the forests of Central Europe took place in prehistoric times. MM. Lartet and Christy say the migration undoubtedly took place before the introduction of domestic animals and the employment of metals in Western Europe. Thus, from the numerous horns and bones of the reindeer, the probable age of the other remains in the caves may be inferred.

Only one of the reindeer horns showed signs of the contemporaneous existence of man. On this one was cut a deep notch. But abundant evidence of the presence of man was otherwise given. In the same cave with the horns, together with flint knives, there had been found a kind of flute made from the tibia of a goat; and in an adjoining cave a whistle, cut out of one of the smaller bones of the reindeer: several of these whistles had previously been discovered in other caves. The most interesting objects in this collection from the caves were a number of needles made from pieces of reindeer horn. Great care had evidently been bestowed on their workmanship, for they were well pointed, and at the thick end pierced with a hole for the thread, which was most likely made of fine strips of the tendons of the reindeer. This animal was not the only one which had left its remains in the caves, for, amongst the collection, bones of the bat, bear, badger, stag, chamois, wild goat, beaver, and wild boar were recognized. It is noticeable, however, that in all these bones there are none belonging to any extinct animal.

The existence of man was shown not merely by articles of his workmanship, but also by his actual remains. Thus, there were two human skulls, a large number of molar teeth, jaws, and various other bones belonging to men, women, and children, and even to a fœtus. One of the jawbones bore traces of a disease which had eaten the bone away in different places. The two skulls are brachycephalic; one, however, was pronounced to be prognathous, and the other orthognathous. All the human bones examined showed that the inhabitants of the caves were men of small stature; and this is also the general conclusion derived from other ancient remains of man. The imaginary idea that the early denizens of the earth were a race of giants, — a belief common among many people, — must certainly be dismissed; for, so far, we are sure that man has not in any way degenerated.

A quantity of black pottery and of ornaments made from shells showed the commencement of human industry at this period; and the existence of intercourse with remote peoples is evident from the fact that the same species of shells are now found as fossils in the tertiary strata of Paris. The bones when found in the different caves were mixed in utter confusion with earth and fragments of stones, showing that some violent action had taken place after the deposition of the remains. The flint implements consisted chiefly of knives and arrow-heads, generally of small size, and were usually found immediately under the human bones, or sometimes associated with them.

From their examination of the ground, the instruments, and the bones, the commission were able to state that the individuals

found in the caves of Furfooz belong to a race succeeding that of the dolichocephalic men of Engis, Moulin-Quignon, etc., and preceding that of the Celto-Germanic age. If this be correct, these people were contemporaneous with the men of Chauvaux, with the troglodytes in the centre of France and the Pyrenees, and with the most ancient dwellers in the lake habitations. Tacitus calls this race the Fenni; they were the ancestors of the present Laplanders, who in every respect greatly resemble the ancient inhabitants of the Furfooz caves. Possibly, to escape from some danger, this race took refuge in caves, where, owing to privation and misery, their stature may have been shortened, and their features rendered uncouth. Skulls of the Reindeer period, from a Belgian bone-cave, indicate a superior as well as an inferior race of primitive men in Europe. Prof. Van Beneden has found in caverns crania of two distinct prehistoric races, of the Reindeer period; and one of them, the least well preserved, is distinctly brachycephalous and prognathous, but with a fine cranial development. The cavern is in the carboniferous limestone, thirty or forty meters above the level of the Lesse. A large number of human remains were found. — *Reader.*

LAKE DWELLINGS OF SWITZERLAND.

In Mr. Lee's translation of Dr. Keller's work on "The Lake Dwellings of Switzerland," are extracts from a work by Professor Heer of Zurich, on the plants found in these dwellings. The latter states that the millets are undoubtedly spring crops; in fact, all the other kinds of cereals appear to have been the same. Consequently, the colonists must have prepared and sown their fields in spring, not in autumn; and the corn was probably housed at the end of summer, and no after-crops secured. Bread was made only of wheat and millet; the latter, with the addition of some grains of wheat, and, for the sake of flavoring it, of linseed also. Barley bread has not yet been found, and it is probable that barley was eaten boiled, or more probably parched or roasted. The small, six-rowed barley of the lake dwellings is the sacred barley of antiquity. The small lake-dwelling wheat (*Triticum vulgare antiquorum*) is probably the oldest sort; it is the most prevalent cereal in all the older lake dwellings, and was cultivated down to the Gallo-Roman times. . . .

Some of the weeds of the corn-fields were indigenous, and others had been introduced with the cultivated plants, and been sown with them. A fact of great interest is the occurrence of the Cretan catchfly (*Silene Cretica*, L.) in the remains of the lake dwellings, as it is not found in Switzerland and Germany; but, on the contrary, is spread over all the countries of the Mediterranean, and is found in the flax-fields of Greece, Italy, the south of France, and the Pyrenees. The presence of the corn bluebottle (*Centaurea cyanea*) is no less remarkable, for its original home is Sicily. As it had already appeared in the corn-fields of the lake dwellings, it indicates the way by which corn had come into the hands of the colonists.

Peas, apples, pears, and some stone fruit have been found.

The apples are chiefly cut into two parts; seldom into three: the smaller ones are left whole. The sour crabs must have been of considerable importance as an article of food, as we may learn from the large quantity of their remains, and their general diffusion amongst the lake dwellings. Together with these wild apples, there were found at Robenhausen a considerable number of a larger kind, which probably were a cultivated variety. Pears must have been less common, for only a few specimens have been found at Wangen and Robenhausen. Remains of the cherry, plum, sloe, grape, and various berries, were also found.

The lake colonists had therefore the same cereals as the Egyptians. They were also clothed in the same manner, for in Egypt flax took the first place amongst the plants used for spinning and weaving. The cultivation of flax, and the art of weaving the thread, may frequently be seen on the Egyptian mural paintings, while hemp was unknown as a plant for making thread; and it is also entirely unknown in the remains of the lake dwellings.

He thinks the antiquity of these dwellings is probably from 1,000 to 2,000 years B. C.

In any case, the remains of plants have a very high antiquity, and they throw some light on the solution of the question whether the species of plants have undergone any change in historic time. With respect to the wild plants, the question must be answered in the negative. The most careful investigation of them shows a surprising agreement with the recent species, and even small varieties of form have been retained, as we see in the water-lily, the fir, the sloe, the bird-cherry, and the hazel-nut. Professor Unger has come to the same result by investigating the Egyptian plants. But the case is different with the cultivated plants, although some kinds — as the dense compact wheat and the close six-rowed barley — have undergone no perceptible change; yet it must be confessed that most of them agree with no recent forms sufficiently to allow of their being classed together. The small Celtic beans, the peas, the small lake-dwelling barley, the Egyptian and the small lake-dwelling wheat, and the two-rowed wheat, form peculiar and apparently extinct races: they are distinguished for the most part from the modern cultivated kinds by smaller seeds. Man has, therefore, in course of time, produced sorts which give a more abundant yield, and these have gradually supplanted the old varieties.

The following are the conclusions drawn by Professor Rutimeyer from the animal remains of these dwellings: —

This seems to be the first place where we can no longer strive against the evidence of a European population who used as food not only the urus and the bison, but also the mammoth and the rhinoceros, and who left the remains of their feasts not only to be gnawed by the wolf and the fox, but also by the tiger and the hyæna. It is, in truth, an old psychological experience, that we always consider that to be really primitive which we see the farthest removed from us, and this in spite of numerous admonitions which are continually pointing out to us stations lying farther and

still farther behind. The investigation of the commencement of human history will hardly have the prerogative of being liberated from the gradual advance which palæontology has followed up. The discovery at Aurignac places the age of our lake dwellings at a comparatively late period, although almost immediately under our peat beds, with their rich treasures, similar antiquities are found; nay, still older remains are met with only a little deeper (in the slaty brown-coal of Dürnten, perhaps forty feet under the bed of the lake of Pfäffikon) than those of Aurignac, which have there been gnawed by hyænas, after having been despoiled of their marrow (like the bones of Robenhausen) by human hands. This last fact would also point out to us the place where we have to look for the remains of the ancestors of the lake settlers, namely, under the glacier moraines; for it is manifest that the people who inhabited the grotto of Aurignac were older than the extension of the glaciers, and consequently also witnesses of this mighty phenomenon. But this fact, on the other hand, takes from us every hope of still finding traces of human existence on places over which the ancient glaciers have passed. Examples showing this in later times are by no means wanting in our country. At all events, the last gap between geological and historical time is now filled up by the discovery at Aurignac. — *Reader*.

ETHNOLOGICAL SUMMARY.

Importance of Philology to Ethnology. — The President of the Geographical Section of the British Association, in his address, in 1866, alluded to a tendency with many ethnologists in their inquiries to disparage the force of the evidence afforded by language, as a key to the history and the relationship of the different sections of mankind to each other. Yet it was impossible to gainsay the absolute co-relation that exists between certain organic forms of speech and some of the great typical divisions of man. Language, in his opinion, constitutes one of the most permanent and indelible tests of race; and no system of ethnology could dispense with the aid of philology. The early utterances of man have become stamped with a certain degree of immortality. The Celtic and the Hindoo, the early Persian, the Hellenic and Latin races betray the community of their origin in the dialectic affinities of the tongues they speak. On the bank of the Tigris and the Euphrates, the Arab employs a language which is the lineal descendant, with few fundamental changes, of that spoken by his forefathers in the days of the Hebrew patriarchs; whilst in the Semitic names scattered along the shores of the Mediterranean Sea and eastern coast of Africa, we have unerring indications of the progress and settlements of early Semitic tribes. However plastic and evanescent, under certain local conditions, characteristic forms of speech may be, they still afford, in the history of man, the key to many of the vicissitudes that have marked his migrations, his conquests, his religion, his social polity, the measure of many of the attributes, by which, as an individual or a race, he is distinguished from his fellow-men.

Ancient Mining. — Interesting discoveries have lately been made in the San Domingo mines of Spain, showing the methods of mining adopted by the ancients. In some of the mines, the Romans dug draining galleries nearly three miles in length; but in others the water was raised by wheels to carry it over the rocks that crossed the drift. Eight of these wheels have recently been discovered by the miners who are now working in the same old mines. The wheels are made of wood, — the arms and felloes of pine, and the axle and its support of oak; the fabric being remarkable for the lightness of its construction. It is supposed that these wheels cannot be less than fifteen hundred years old, and the wood is in a perfect state of preservation, owing to its immersion in water charged with the salts of copper and iron. From their position and construction, the wheels are supposed to have been worked as treadmills, by men standing with naked feet upon one side. The water was raised by one wheel into a basin, from which it was elevated another stage by the second wheel, and so on for eight stages. — *The Miner, San Francisco, Cal.*

Ancient Bronzes. — M. Fellenberg, of Berne, as the result of a long series of anaylses of ancient bronzes, in which he gives their composition and probable origin, sums up his opinions on the subject as follows: The first knowledge of bronze might have been brought to the tribes of the bronze period either by the Phœnicians or by some other civilized people living further towards the south-east; but it then became a common property, and to a certain extent the type of a whole epoch of civilization. It maintained and spontaneously developed itself, until, by the introduction and preponderant diffusion of iron, the general and exclusive use of bronze, and at the same time the bronze period, came to an end.

The Age of Stone, in France. — M. Gervais has described the bones found in a natural excavation, several yards long, in Baillargues, France, which had been used as a burial-place in the age of stone. The bones were those of adults, and some indicated an advanced age; in one case the femur was 0.465 metre long. A cranium, presented to the Academy of Sciences, had the typical form of the white race, it being brachycephalous, without a trace of prognathism, and a well-developed forehead. The flint implements found indicated the age to which the people belonged. He concludes, from the bones and other objects found, that during the age of stone the country of Castries and much of Southern France were inhabited by the race here indicated.

Lake Habitations. — The recent discoveries of M. Messikomer of Zurich, in the large turf-bed near Robenhausen, though they do not give the key to the chronological enigma of the pale buildings and their inhabitants, throw considerable light on their manner of living and the condition of their civilization. It has been found that on this curious spot there were three of these old settlements, one on the top of the other. The two oldest settlements had been destroyed by fire, but the third, the pales of which do not consist of round wood, had been abandoned and not destroyed. All three settlements belong to the stone period; not the slightest trace of

bronze or iron had been found, demonstrating very conclusively the distinct separation and length of duration of the prehistoric so-called stone and bronze periods. These settlements on the borders of Lake Constance are the largest and best-preserved of any of the large lake villages of the stone period.

Those desirous of pursuing the subject of the early European races are referred to a very full article on this subject in the "Quarterly Journal of Science," for July, 1866.

OBITUARY

OF MEN EMINENT IN SCIENCE. 1865, 1866.

Barth, Dr. Henry, the African Explorer, 1865.
Blunt, Edmund, an American Hydrographer, Sept. 2, 1866.
Brande, William T., English Chemist, Feb. 11, 1866.
Cuming, Hugh, English Conchologist, Aug. 10, 1865.
Dufour, Leon, French Entomologist, April 18, 1865.
Eastlake, Sir Charles, English Painter, 1865.
Encke, Johann Franz, German Astronomer, Aug. 26, 1865.
Fitzroy, Admiral, English Meteorologist, May, 1865.
Forchhammer, Dr., Danish Geologist, Dec. 1865.
Gibbes, Dr. Robert W., American Geologist, Sept. 1866.
Goldschmidt, Hermann, French Astronomer, noted as the Discoverer of Asteroids, Aug. 20, 1866.
Gould, Dr. Augustus A., American Naturalist, Sept. 15, 1866.
Gressly, A., Swiss Geologist, 1865.
Greville, Dr. Robert K., English Botanist, 1866.
Hamilton, Sir William Rowan, English Physicist, Sept. 12, 1865.
Harvey, William Henry, English Botanist, May 15, 1866.
Hooker, Sir William J., English Botanist, Aug. 12, 1865.
Kennicutt, Robert, American Naturalist, May 13, 1866.
Kupffer, S. Von, Russian Meteorologist, 1865.
Lereboullet, Dom. A., French Geologist, Oct. 6, 1865.
Lindley, Dr. John, English Botanist, Nov. 1, 1865.
Lubbock, Sir John W., English Geologist, June, 1865.
McLaren, Charles, English Geologist, 1866.
Montagne, J. F. C., French Botanist, Jan. 5, 1866.
Oppul, Prof., Bavarian Geologist, 1866.
Paxton, Sir Joseph, English Architect, June 8, 1865.
Porter, Prof. John A., American Chemist, Aug. 25, 1866.
Reeve, Lowell, English Conchologist, Nov. 18, 1865.
Remak, Prof., Prussian Anatomist, 1865.
Richardson, Sir John, English Naturalist, and Arctic Voyager, June 5, 1865.
Riddell, Dr. J. L., American Naturalist and Microscopist, October 7, 1865.
Rogers, Prof. Henry D., American Geologist, Professor in Glasgow University, May 29, 1866.
Sæman, Louis, French Mineralogist, August 23, 1866.
Schomburgk, Sir Robert H., German Botanist and Traveller, March 11, 1865.
Schott, Heinrich, German Botanist, Feb. 5, 1865.
Silbermann, M., French Physicist, July, 1865.
Smith, Admiral William H., English Astronomer, Sept. 9, 1865.
Uhler, Dr. William M., American Chemist, Nov. 27, 1865.
Valenciennes, Prof., French Zoölogist, and contemporary of Cuvier, April 12, 1865.
Whewell, Dr., English Physicist, March 10, 1866.
Woodward, S. P., English Geologist, July, 1865.

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